Australian Government

Australian Radiation Protection and Nuclear Safety Agency

arpansa

ACDS IN REVIEW

2020 2021

10 YEARS OF ACDS AUDITS 2011–2021

AUSTRALIAN CLINICAL DOSIMETRY SERVICE

Welcome to the ACDS 2020–21 ***Year in Review;***
a publication of the Australian Clinical Dosimetry Service (ACDS)

It has been an extraordinary 12 months for the ACDS as we have continued to deliver and develop our dosimetry audit program that is essential to the safety of patients receiving radiation therapy treatment across Australia and New Zealand.

This year we recognise and celebrate 10 years since the formal launch of the ACDS in February 2011. What began as a voluntary national auditing service offered free of charge to Australian radiation oncology facilities is now a sustainable and cost-recovered service offered by the Federal Government's Australian Radiation Protection and Nuclear Safety Agency. As of 30 June 2021, the ACDS is subscribed to by 99% of Australian and 50% of New Zealand radiation oncology providers.

ACDS audits support Radiation Oncology Health Program Grants funding, Trans Tasman Radiation Oncology Group (TROG) clinical trial credentialing and offer benchmarking data across Australia and New Zealand facilities. The ACDS is ISO/IEC 17025 accredited by the National Association of Testing Authorities (NATA) and has a memorandum of understanding with the Imaging and Radiation Oncology Core (IROC) whereby our Level I mail-out audits are comparable with IROC for international trial credentialing. Our comprehensive radiotherapy audit services are recognised as meeting the Radiation Oncology Alliance Radiation Oncology Practice Standards criteria for independent dosimetric comparison/audit.

This last financial year has seen us record our highest ever number of on-site audits in a year, despite the unpredictable challenges and limiting restrictions of COVID-19. It speaks to the experience and expertise of our staff that we have continued to expand and develop the service under challenging conditions while working remotely, sometimes after quarantine and through isolation. More information on ARPANSA's response to COVID-19 is outlined on page 18.

We continue to share what we learn through our audits and research. Many of our staff represented the ACDS at both national and international conferences and scientific meetings (virtually) during the 2020–21 period. In recognition of the work of the ACDS and its contribution to radiation safety, we congratulate Maddison Shaw, Jessica Lye and the ACDS team for publications in international journals on measuring dose to bone and reporting dose to medium respectively. More details can be found in the *Publications and presentations* section.

The ACDS has also continued its work developing audits for emerging radiotherapy techniques such as stereotactic radiosurgery and online adaptive radiotherapy. Acquisition of a magnetic resonance safe motion management phantom and PhD student recruitment, strengthen our ability for audit development.

Our work continues to meet the performance objectives outlined in ARPANSA's Corporate Plan and the ACDS strategic plan as we continue to work towards our vision of being a world-leading dosimetry audit service recognised for the highest level of quality and patient safety in radiation therapy.

Rhonda Brown
Director ACDS

Carl-Magnus Larsson
CEO of ARPANSA

Acknowledgement of Country

The Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) respectfully acknowledges Australia's Aboriginal and Torres Strait Islander communities and their rich culture and pays respect to their Elders past and present. We acknowledge Aboriginal and Torres Strait Islander peoples as Australia's first peoples and as the Traditional Owners and custodians of the land and water on which we rely.

We recognise and value the ongoing contribution of Aboriginal and Torres Strait Islander peoples and communities to Australian life and how this enriches us. We embrace the spirit of reconciliation, working towards the equality of outcomes and ensuring an equal voice.

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ACDS overview

Our vision

A world-leading dosimetry auditing service known for the highest level of quality and patient safety in radiation therapy.

Our mission*

To guide, support and improve patient safety and radiotherapy service delivery by:

providing a comprehensive suite of audit modalities covering all common clinical practices

improving national dosimetry capabilities in clinical treatment delivery

offering our services to Australian and overseas radiotherapy centres on a fee-for-service basis.

Our structure

The Director of the ACDS, Rhonda Brown, has held this position since January 2021 after being in the role of Acting Director since June 2020. Rhonda leads a skilled team of medical physicists, radiation therapists and support staff, who work together to deliver on the ACDS strategic objectives, and supporting ARPANSA's strategic direction.

The ACDS forms part of the Medical Radiations Services Branch at the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) along with the Primary Standards Dosimetry Laboratory (PSDL), who maintain the Australian primary standard for absorbed dose. The PSDL calibrate the detectors used in ACDS audits against this primary standard, underpinning the quality of the dosimetry checks.

Research and audit development are aligned with current and emerging clinical practice. The Roger Allison Radiotherapy Quality Centre, opened in March 2019, provides essential access to a modern linear accelerator (linac). The ACDS physicists were instrumental in the acceptance and commissioning of this Elekta VersaHD linac and we continue to maintain ongoing quality assurance. This is an essential resource for audit development for modalities including stereotactic ablative body radiotherapy (SABR), stereotactic radiosurgery (SRS), and most recently the Level III 4D motion adaptive audit utilising our newest phantom; a magnetic resonance imaging compatible CIRS phantom with motion capabilities and simulated lungs, liver, kidney and spine.

Currently, 99% of Australian and 50% of New Zealand radiation oncology providers, subscribe to the ACDS for quality assurance audits. Using information gathered during audits across the facilities, the ACDS provides data for benchmarking allowing individual facilities to measure their performance against other radiotherapy facilities with similar resources.

Our staff


RHONDA BROWN


MADDISON SHAW


SABEENA BEVERIDGE


ANDREW ALVES


KATH METZGER


ANDREW COLE


FAYZ KADEER


JULIE GIBLETT


DANIELA D'ANTONIO


JEREMY SUPPLE


MAX HANLON


CATE DAVEY


RAYMOND SUN


ALEX BURTON


LLOYD SMYTH


KATHERINE COLLINS

Our associates and external auditors


IVAN WILLIAMS
Chief Medical Radiation Scientist, ARPANSA


JOERG LEHMANN
ROMP External Auditor


JESSICA LYE
External Auditor


JOHN KENNY
ROMP Consultant


FRANCIS GIBBONS
ROMP External Auditor


JOHNNY LABAN
External Auditor


STEPHANIE KEEHAN
ROMP External Auditor

The mission of the ACDS is fully aligned with ARPANSA's strategic objective 3: Promote the safe and effective use of radiation in medicine.

Our strategic plan

The ACDS Strategic Plan 2018–2022 sets out our strategic objectives over 4 years. It is aligned with ARPANSA's 4-year Corporate Plan, notably ARPANSA's Strategic Objective 3: *Promote the safe and effective use of ionising radiation in medicine*.

We are confident that the dedicated and knowledgeable ACDS staff, with the support of ARPANSA and advice from the Clinical Advisory Group, will continue to deliver quality services to the Australian and New Zealand health care system for the benefit of patient safety.

Our strategic objectives

1. **Be recognised as a global leader and associated with the highest standards of quality and safety in radiotherapy**

2. **Be the provider of auditing services to all Australian and New Zealand radiotherapy facilities**

3. **Be recognised as the leading dosimetry audit experts nationally and in the Asia-Pacific region**

4. **Offer competitive quality services that cover all clinical practices and emerging technologies**

5. **Positively influence the use of radiation in medicine and have tangible impact benefitting patient safety**

Our governance

The Clinical Advisory Group

The Clinical Advisory Group (CAG) comprises members across all jurisdictions and practices who have a broad base of professional clinical experience.

The CAG members are nominated by their professional bodies* to advise the ACDS on development of audit methodologies and provide immediate clinical interpretation of specific audit outcomes. In addition to this, they review phantom design, measurement techniques and provide advice on relevant treatment techniques and modalities for audits, and on what skills, experience, and training is required for ACDS auditing staff.

The CAG meets quarterly and out of session, if necessary, to discuss audit results that could potentially pose a risk to the safety of patients receiving radiation therapy.

The CAG continues to be an invaluable source of experience and support as they have been since the beginning of the ACDS. This independent expert team now forms part of ARPANSA's governance structure, along with the Radiation Health and Safety Advisory Council (RHSAC), the Nuclear Safety Committee (NSC) and the Radiation Health Committee (RHC). Since the completion of the ACDS Oversight Committee in December 2020, the CAG in it's capacity as ACDS' advisor, is now appointed by the CEO of ARPANSA (as specified in their terms of reference) and report yearly to the Australian Health Protection Principal Committee (AHPPC).

Clinical Advisory Group members

ALLAN FOWLER (CHAIR)
RANZCR, NSW

NICK HARDCASTLE
TROG

JOHN SHAKESHAFT
ACPSEM

ALBERT TIONG
RANZCR

ANDREW COUSINS
ACPSEM
NEW ZEALAND

KATE FRANCIS
ASMIRT

TOMAS KRON
INDEPENDENT
TECHNICAL EXPERT

**Professional bodies consist of the Royal Australian and New Zealand College of Radiologists (RANZCR), Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM), Trans-Tasman Radiation Oncology Group (TROG), Australian Society of Medical Imaging and Radiation Therapy (ASMIRT) and the New Zealand Institute of Medical Radiation Technology (NZIMRT).*

ACDS Oversight Committee and the Australian Health Protection Principal Committee

The governance structure of the ACDS has changed with the role of the ACDS Oversight Committee coming to an end in December 2020. The ACDS Oversight Committee was formed by the Australian Health Ministers' Advisory Council (AHMAC) to assist with ACDS's transition from being a Commonwealth-funded organisation to a sustainable cost-recovered subscription service. ARPANSA and the ACDS staff sincerely thank the contributing members for their work and commitment to the service during their governance.

The ACDS now reports to the Australian Health Protection Principal Committee (AHPPC) annually. The AHPPC is the key decision-making committee for health emergencies and health protection issues of national significance. This committee comprises all state and territory Chief Health Officers and is chaired by the Australian Chief Medical Officer. The ongoing role of the AHPPC is to advise the Health Chief Executives Forum (formerly AHMAC) on health protection matters and national priorities, as well as mitigating emerging health threats related to infectious diseases, the environment, and natural and human made disasters.

Supporting research and clinical trials

STRATEGIC OBJECTIVES

*Ensuring the **highest standards** of quality and safety in radiotherapy for our patients*

Supporting robust research in radiation therapy is one of the functions of the ACDS. This is achieved through a strong relationship with the Trans-Tasman Radiation Oncology Group (TROG) who we collaborate with to develop audits that support clinical trial credentialing. The ACDS is an observer member of the Global Quality Assurance of Radiation Therapy Clinical Trials Harmonization Group (GHG) whose goal it is to promote harmonisation of radiotherapy quality assurance between clinical trial groups globally.

ACDS audits may be used towards clinical trial accreditation for TROG trials as they demonstrate that trial participants meet the quality assurance requirements necessary for robust research. It is important to note that audits still in field trials are accepted by TROG as evidence that trial participants meet credentialing criteria.

TROG CANCER RESEARCH

www.trog.com.au

CLINICAL TRIALS THAT THE ACDS PROVIDE CREDENTIALING FOR

Level II/III		
3DCRT/IMRT/VMAT	**SABR**	**SRS**
ANZ 1601/BIG 16-02 EXPERT	CTC 0245/AGITG AG0118PS/TROG 18.04 MASTERPLAN	TROG 17.02 OUTRUN
AGITG AG0407GR/TROG 08.08 TOPGEAR	TROG 15.03 FASTRACK II	TROG 16.02 LOCAL HER-O
R2810-ONC-1788/TROG 17.11 C-POST	TROG 18.01 NINJA	EORTC 1308/TROG 15.02 ROAM
TROG 18.06 FIG	PMC 17/013/TROG 17.05 AZTEC	
ANZUP 1801 DASL-HiCaP	TROG 17.03 LARK	
TROG 20.01 CHEST-RT	VCCC/TROG 20.03 AVATAR	
MASC 2101 i-MAT	TROG 19.06 DECREASE	

Horizon scanning – particle therapy

The ACDS is preparing to conduct Level Ib and III dosimetry audits at the SAHMRI Proton Centre in Adelaide when it opens ~2023. As a part of the scoping work, the ACDS is participating in the Global Harmonization Group's harmonisation of Proton vs Photon quality assurance, to ensure that developed procedures are in line with international best practice. The ACDS will work in collaboration with PSDL during audit development.

ACDS accreditation requirements

The ACDS is an ISO/IEC 17025 accredited audit service which provides dosimetry audits to meet:

- Radiation Oncology Alliance Radiation Oncology Practice Standards (a peak group comprising the four key specialties in radiation oncology and representing their respective organisations RANZCR, ASMIRT, ACPSEM and CNSA)
- Radiation Oncology Health Program Grants (ROHPG) (Australia) funding conditions
- jurisdictional radiation license requirements.

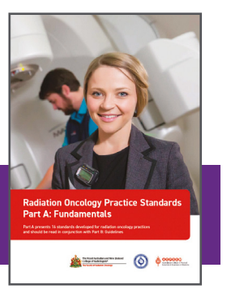
NATA
WORLD RECOGNISED ACCREDITATION
NATA Accredited Laboratory 14442

The ACDS forms part of the ARPANSA corporate ISO/IEC 17025 National Association of Testing Authorities (NATA) accreditation. This is a competency-based standard which requires the ACDS, and the 6 other ARPANSA laboratories, to undertake a rigorous internal and external auditing program, focused on the competence of the employees to perform the work.

The NATA are the external certification body who perform a surveillance audit and re-assessment audits every 18 months thereafter. These re-assessment audits require the use of an external technical expert in ACDS' field of radiotherapy dosimetry. As ACDS is the peak body in Australia, we use equivalent experts from around the world to perform these technical assessments of ACDS staff.

Further information regarding NATA accreditation, the ACDS or the ARPANSA management system, can be obtained by contacting our quality manager via qualitymanager@arpansa.gov.

ACDS audit services are recognised as meeting the Radiation Oncology Alliance Radiation Oncology Practice Standards (ROPS) criteria for independent dosimetric comparison/audit.



Global affiliations

STRATEGIC OBJECTIVES

International collaboration

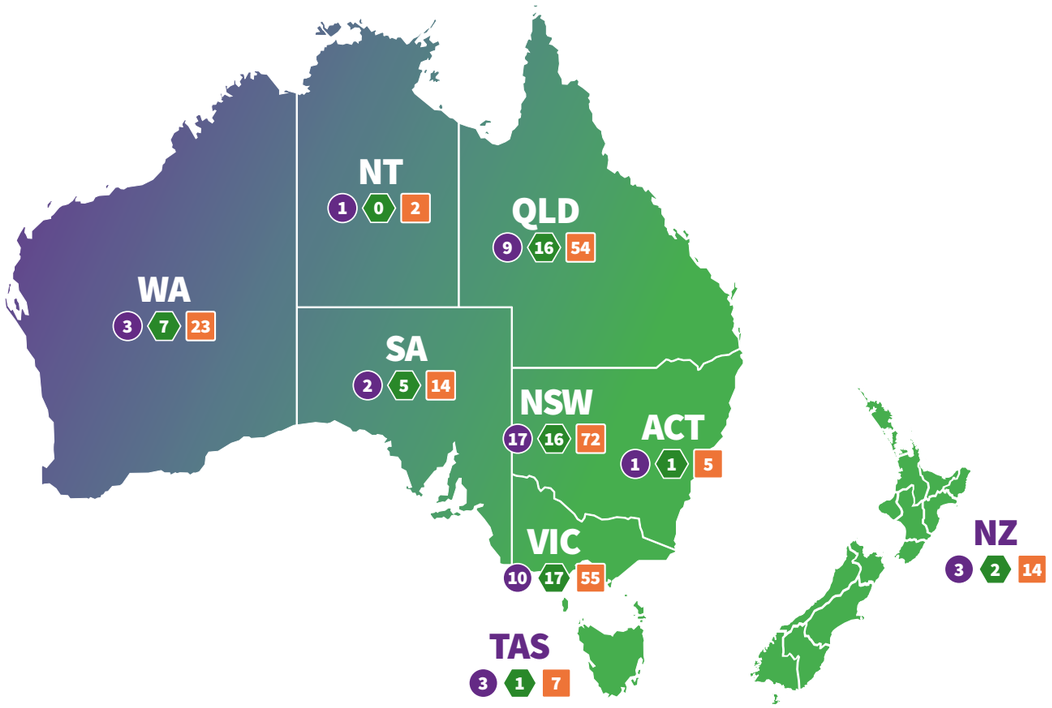
Global Harmonization Group

The ACDS is an observer member of the Global Quality Assurance of Radiation Therapy Clinical Trials Harmonization Group (GHG). The group consists of clinical trial quality assurance offices and auditing bodies around the world and aims to harmonise and improve clinical trial quality assurance in radiation therapy worldwide.

Imaging and Radiation Oncology Core (IROC)

The ACDS and IROC Houston QA Center, have a memorandum of mutual recognition agreement of dosimetric audit equivalence for the ACDS Level I optically stimulated luminescence dosimeters (OSLD) audits. The agreement recognises the technical equivalence and frequency of both organisations' OSLD mail-out audits. In practise, this means that a facility may provide ACDS Level I OSLD results where there is a requirement for an IROC OSLD audit, such as in a clinical trial. This agreement is maintained by regular intercomparisons of the mail-out audit by the ACDS and IROC.

National and International audit coverage



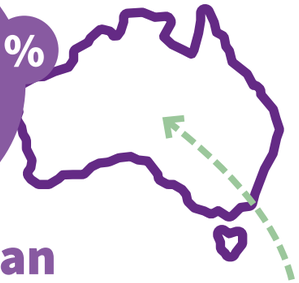
# PUBLIC FACILITIES	# PRIVATE FACILITIES	# LINEAR ACCELERATORS

ACDS 2020–21 by the numbers

STRATEGIC OBJECTIVES

2

99%



of Australian
radiotherapy providers subscribe to the ACDS

Approximately
70,000 patients
across Australia alone receive radiotherapy each year. All benefit from the services of the ACDS

50%

of New Zealand
radiotherapy providers subscribe to the ACDS

this covers
44 per cent
of all NZ linacs

This year, the ACDS has completed the
highest yearly number of on-site audits
since the beginning of the ACDS despite restrictions imposed by the pandemic

131 **on-site audits** including...
- 25 field trials
- 17 follow-up audits

101 **linacs** covered by...
- 42 facility mail out audits

39 **recommendations made to facilities**
for the 20/21 FY

LIb	LII	LIII
0	15	24

2 Peer-reviewed publications

9 Presentations *(2 international online)*

2 Posters *(1 international online)*

Staff spent:

336 days relocated interstate or in NZ

62 days in quarantine

45 days in isolation

82 **Total flights** taken by ACDS staff

9 **Travel exemptions** granted to staff

ARPANSA and working through COVID

STRATEGIC OBJECTIVES

*The ability of the ACDS to perform on-site audits was **severely challenged during 2020–21** due to the initial national lockdown, followed by Victoria's '100 days' of lockdown beginning July 2020.*

In recognition of the vital role that the ACDS perform in providing safe radiation therapy delivery to approximately 70,000 patients annually, ARPANSA engaged with every state and territory regulator in Australia and achieved policy agreement that ACDS audits were essential. The regulators recognised that the COVID pandemic would be impacting all aspects of life for some time and ensuring safe cancer therapy would continue to be essential. The regulators agreed they would support ACDS applications to enter their state or territory to conduct audits. The ACDS were to engage with the hospitals and obtain agreement to enter and perform these essential audits.

The national and then Victorian lockdowns meant that some audits could not be performed as scheduled and that facilities could not provide the required evidence of audit to the Radiation Oncology Health Program Grants (ROHPG) office. When the resulting uncertainty arose around eligibility of reimbursement for ROHPG payments, the ACDS proposed an interim solution in the form of remote mail-out OSLD audits. Upon consultation, the ROHPG agreed with the solution which was then implemented by the ACDS. Consequentially, ROHPG recognised that providers had met their auditing conditions and would continue to receive funding for the 2020-21 financial year.

The ACDS have implemented new work and operational strategies to continue to offer auditing in the challenging COVID environment. ARPANSA has supported extended travel campaigns, temporary relocations for staff and their families for months at a time, and continuous close consultation with jurisdictional regulators. The ACDS has modified its operating procedures to respond to the requirements of individual hospital infection control departments ensuring auditing can continue without compromising the safety of hospital staff and patients. These measures will stay in place whilst we continue to work through instant jurisdictional lockdown and border closures in order to provide a national auditing program. Our customers' commitment to working with the ACDS for the benefit of radiation safety is integral to our success in working through this pandemic. We would like to acknowledge how grateful we are for their patience and consideration.

Audit development and research

STRATEGIC OBJECTIVES

Stereotactic ablative body radiotherapy (SABR)

SABR audits are now live!

The ACDS Level III SABR audit commenced operations in 2018 and has been released as a live modality from 1 July 2021. After completing field trial audits at over 75 radiation oncology facilities across Australia and New Zealand, the ACDS have an extensive dataset with over 300 radiotherapy plans measured to date. The audit includes soft tissue, spine and lung cases which reflect the most common tumour sites treated clinically with a SABR approach. The SABR audit is applicable to conventional linac, Halcyon™, Ethos™, TomoTherapy® and CyberKnife® systems, and can be used towards credentialing for TROG clinical trials.

The SABR audit utilises the ACDS CIRS thorax phantom which is equipped with a realistic human spine and lungs. The primary detector used for measurement of each case is Gafchromic™ EBT3 film, with secondary measurements using PTW microDiamond point dose detectors. The primary scoring metric determining the outcome of each case is the gamma pass rate observed on the film, using a gamma criterion of 5%/2 mm. Out of tolerance limits are also placed on the Gafchromic™ film distance-to-agreement (DTA) between planned and measured isodose lines, and the local point dose variation. The scoring metrics, detailed in Table 1, were determined in consultation with the Clinical Advisory Group, taking into consideration the audit uncertainties and clinical relevance. The ACDS has a significant amount of mature field trial data, as shown in the ANZ dataset of audit results (Figure 1).

TABLE 1: SCORING CRITERIA FOR SABR AUDIT

Metric	Criteria	Pass (optimal level)	Pass (action level)	Out of tolerance
Gamma criteria All cases	5%/2 mm	≥ 95%	< 95% and ≥ 90%	< 90%
Soft tissue 1D profile DTA	Mean DTA @ 70% isodose (L-R) and (A-P)			> 3 mm
Spine 1D profile DTA	Mean DTA @70% isodose (L-R) DTA at PTV-spinal cord PRV interface @70% isodose (A-P)			> 2 mm
Lung 1D profile DTA	Mean DTA @ 70% isodose (S-I)			> 3 mm
Local dose variation All cases	100% points			> 8%

Backed by a peer-reviewed publication, essential research undertaken by the ACDS has advanced film dosimetry. This novel work, shared with and recognised by the scientific community, has resulted in the determination of medium corrections which are necessary for returning the true dose absorbed by various tissue types within the patient.

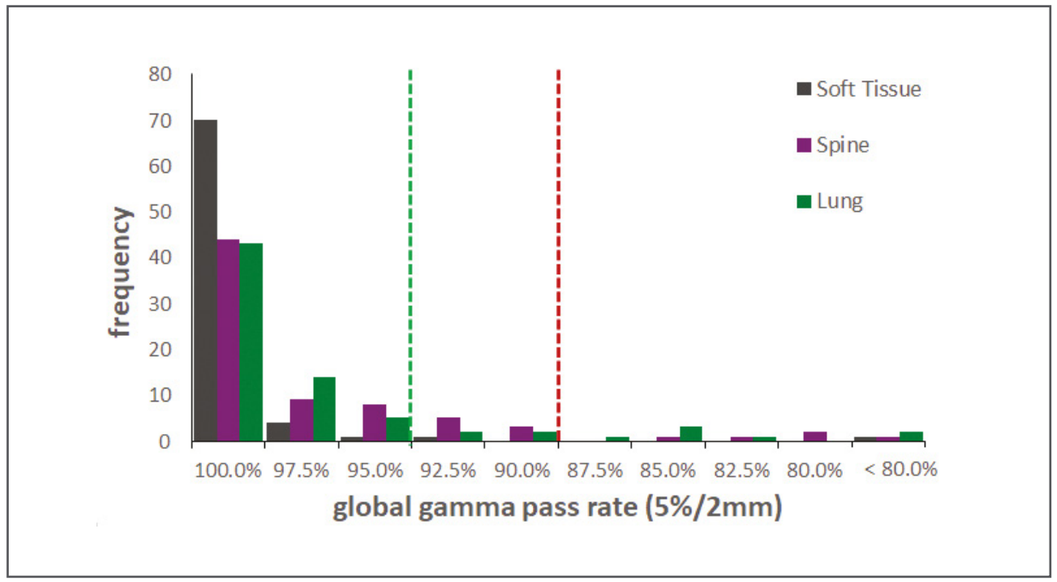


FIGURE 1

Figure 1: ANZ dataset of SABR audit Gafchromic™ film results with medium dependent corrections applied (gamma passing rate 5%/2mm). The dashed lines show the Pass (Action Level) and Out of Tolerance thresholds.

The Global Harmonization Group has published recommendations that dose-to-medium calculations should be reportedin clinical trials where available. The work of the ACDS in film dosimetry and medium corrections, was a major contributor to this paper. Kry S, Lye J, et. al., (2021)

Audit development and research

STRATEGIC OBJECTIVES

Stereotactic ablative body radiotherapy (SABR) *continued*

The ACDS microDiamond and Gafchromic™ film detectors are calibrated in water but are surrounded by bone or lung equivalent materials during measurement (rather than soft tissue equivalent plastic or water). For the measurement in these non-water-equivalent materials, the ACDS applies medium-dependent corrections, reporting both dose-to-scaled density water (D_w) and dose-to-medium (D_m). In the Level III SABR audit, dose is calculated both ways, using the respective Dw and Dm corrections. The outcome of the audit is tailored according to the algorithm that was used by the facility to report dose. Further details of the applied corrections can be found in the publication by Shaw et. al. (2021) Measuring the dose in bone for spine stereotactic body radiotherapy - https://doi.org/10.1016/j.ejmp.2021.03.011.

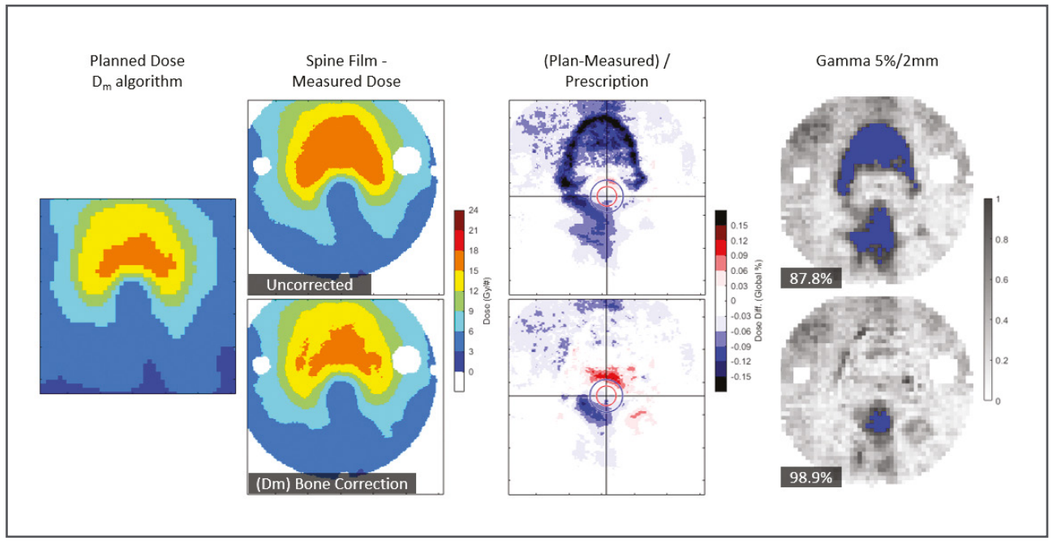


FIGURE 2

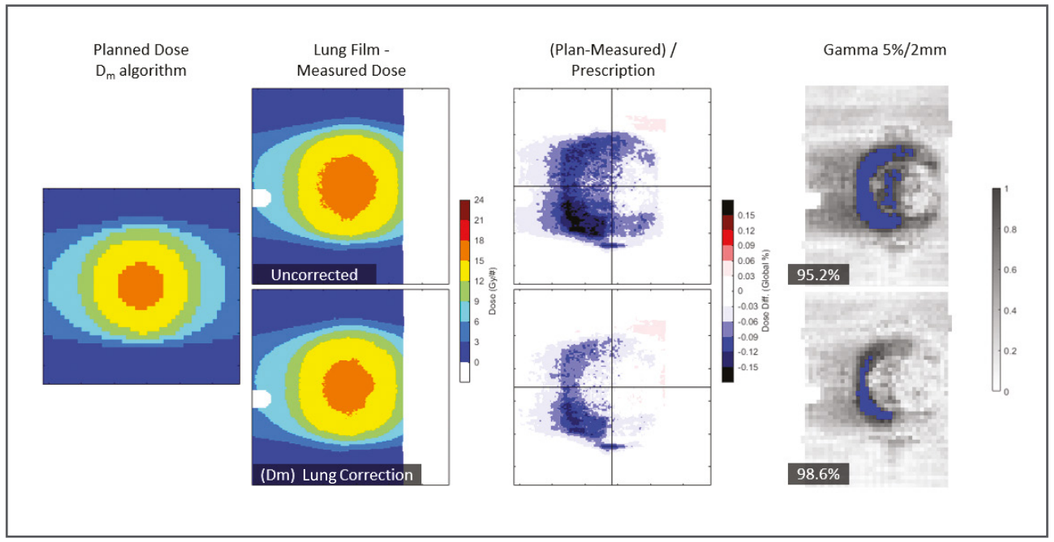


FIGURE 3

Figure 2 and 3: Examples of film dose corrected pixel by pixel according to the medium surrounding respective areas of the film. A comparison is made between corrected and uncorrected film. Dose measured in the presence of bone once corrected achieves closer agreement with the treatment planning system which also calculates dose absorbed by the various tissue types.

Measuring the dose in bone for spine stereotactic body radiotherapy

https://doi.org/10.1016/j.ejmp.2021.03.011

Report dose-to-medium in clinical trials where available; a consensus from the Global Harmonisation Group to maximize consistency

https://doi.org/10.1016/j.radonc.2021.03.006

Audit development and research

STRATEGIC OBJECTIVES

Stereotactic radiosurgery (SRS)

The SRS audit, currently in field trial, now supports clinical trial credentialing for EORTC 1308/TROG ROAM, TROG OUTRUN and LOCAL HER-O brain metastases trials.

Field trial audits have progressed and have been conducted across every platform currently treating with SRS in Australia, including HyperArc, CyberKnife® and Gamma Knife®, using a common audit protocol. Over 150 plans have been measured across 14 audits and 179 films have been processed. The 3 metrics analysed were: gamma analysis; 5%/1 mm, geometric precision and point dose variation.

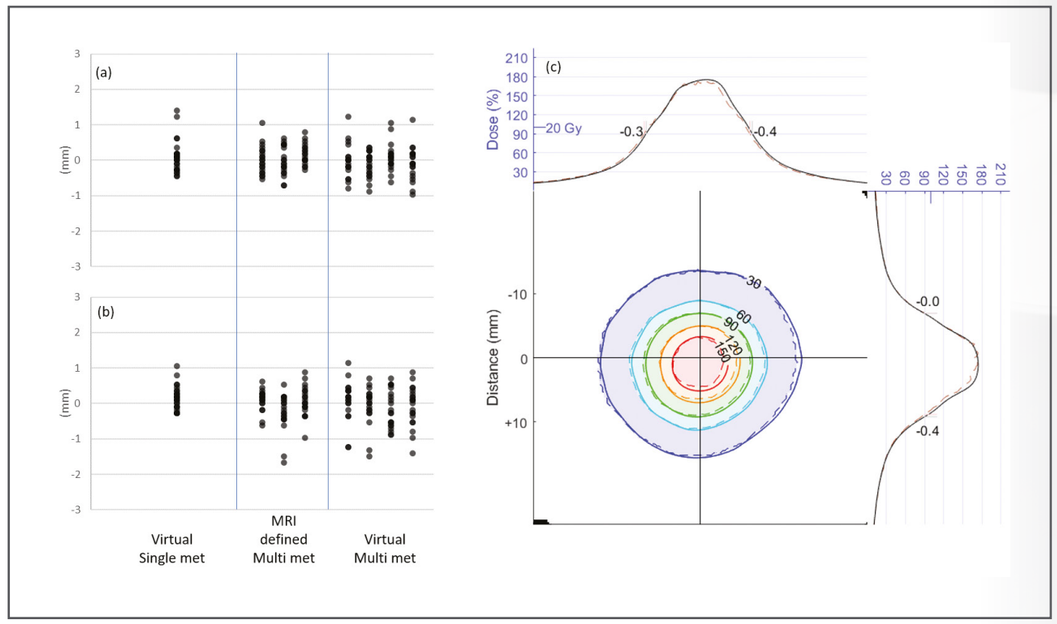


FIGURE 4

Figure 4: Relates to the geometric precision metric. The image on the right displays the correlation between the location of the planned dose distribution and the location of the measured dose distribution. The closer the dashed lines are to the solid lines, the more precise the treatment delivery. The image on the left indicates variation in agreement between planned and delivered dose, for the different audit cases.

Below: Gamma Knife® immobilisation for the ACDS 'Max' head phantom

Audit development and research

STRATEGIC OBJECTIVES

Film dosimetry and analysis

We are building software tools that enable our capabilities. These are independent from commercial systems, giving us control over our film calibration workflow and further improving the quality of our audits.

The ACDS uses Gafchromic™ EBT3 film for the LIII SABR and SRS audits. MicroDiamond detector measurements taken during the audits provide data relating to point doses, with the film analysis providing 2D dose maps for comparison with plan data. Film serves as a primary dosimeter with point dose measurements taken for quality control and immediate on-site dosimetric feedback during the audit.

The ACDS has developed 2 in-house film dosimetry software packages which are independent from available commercial systems and have been purpose built to fit within the ACDS audit workflow.

Now fully tested and commissioned, DAFFODIL (Dynamic Analysis For Film Optical Density ILlustration) was developed to generate absolute dose maps from scanned film images. The software gives us control over the film calibration workflow and has returned a significant improvement in analysis efficiency and repeatability.

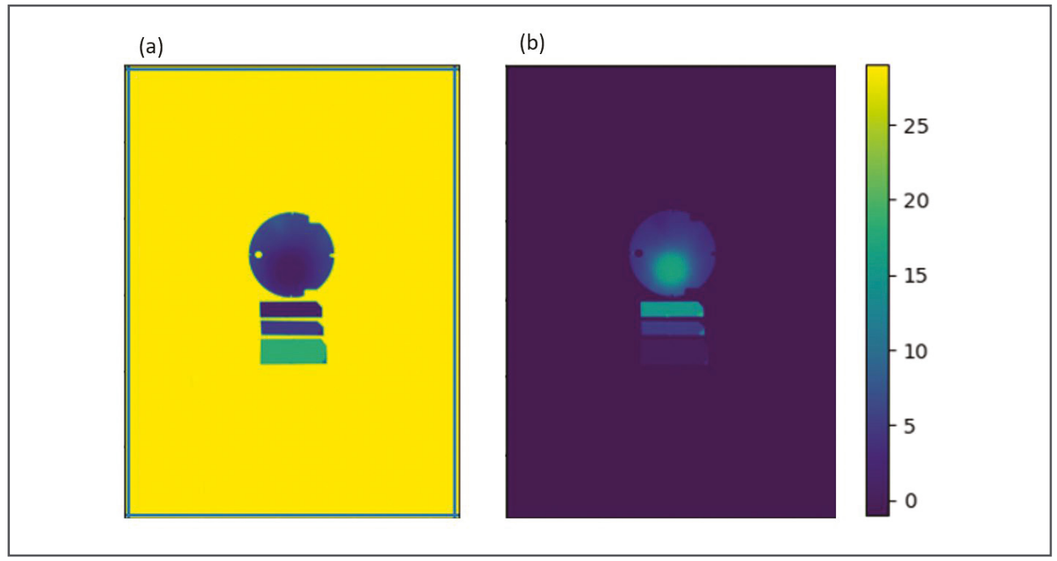


FIGURE 5

Figure 5: Dose mapping using DAFFODIL. Image A shows optical density map of the audit and control films on the scanner bed while Image B shows the absolute dose in Gray.

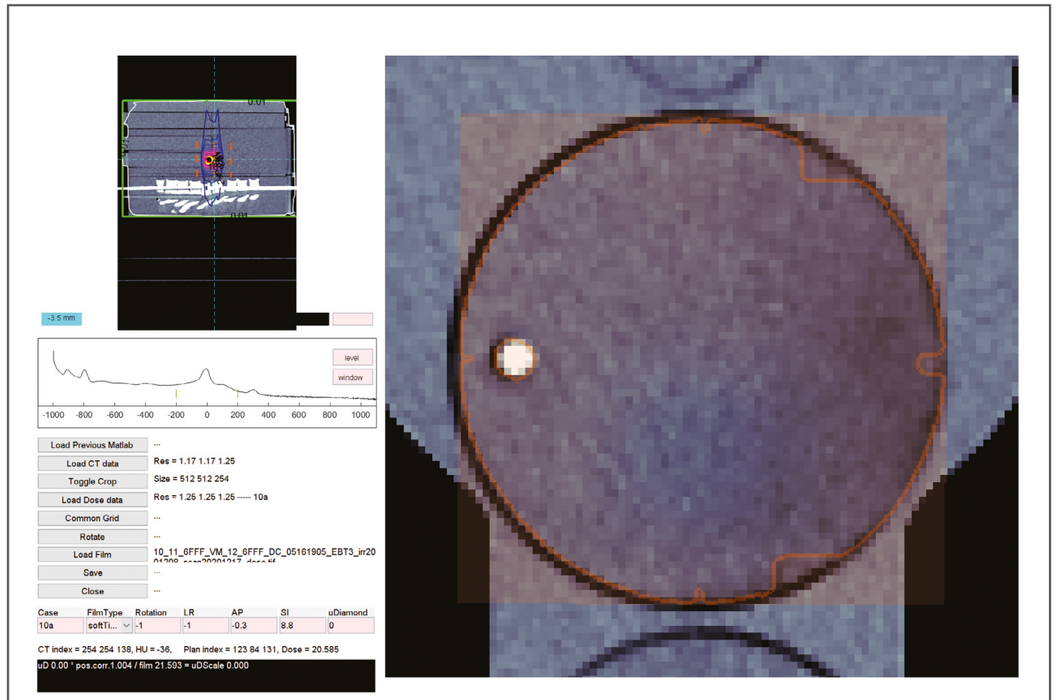


FIGURE 6

Figure 6: Screenshot of the film-to-CT match in MARIGOLD, when the film is aligned with its location in the phantom during the audit. This allows for comparison between the location of the measured dose with the location of the planned dose, evaluating accuracy of treatment delivery.

MARIGOLD (Matlab Analysis and RegIstration, Gamma Or Linear DTA) is used to align the film to the CT image of the phantom. The purpose of the match is to locate the film prior to the comparison between the measured and planned dose distributions.

After the alignment is complete MARIGOLD produces dose-difference maps, distance-to-agreement results, and a gamma analysis for each film.

Audit development and research

STRATEGIC OBJECTIVES

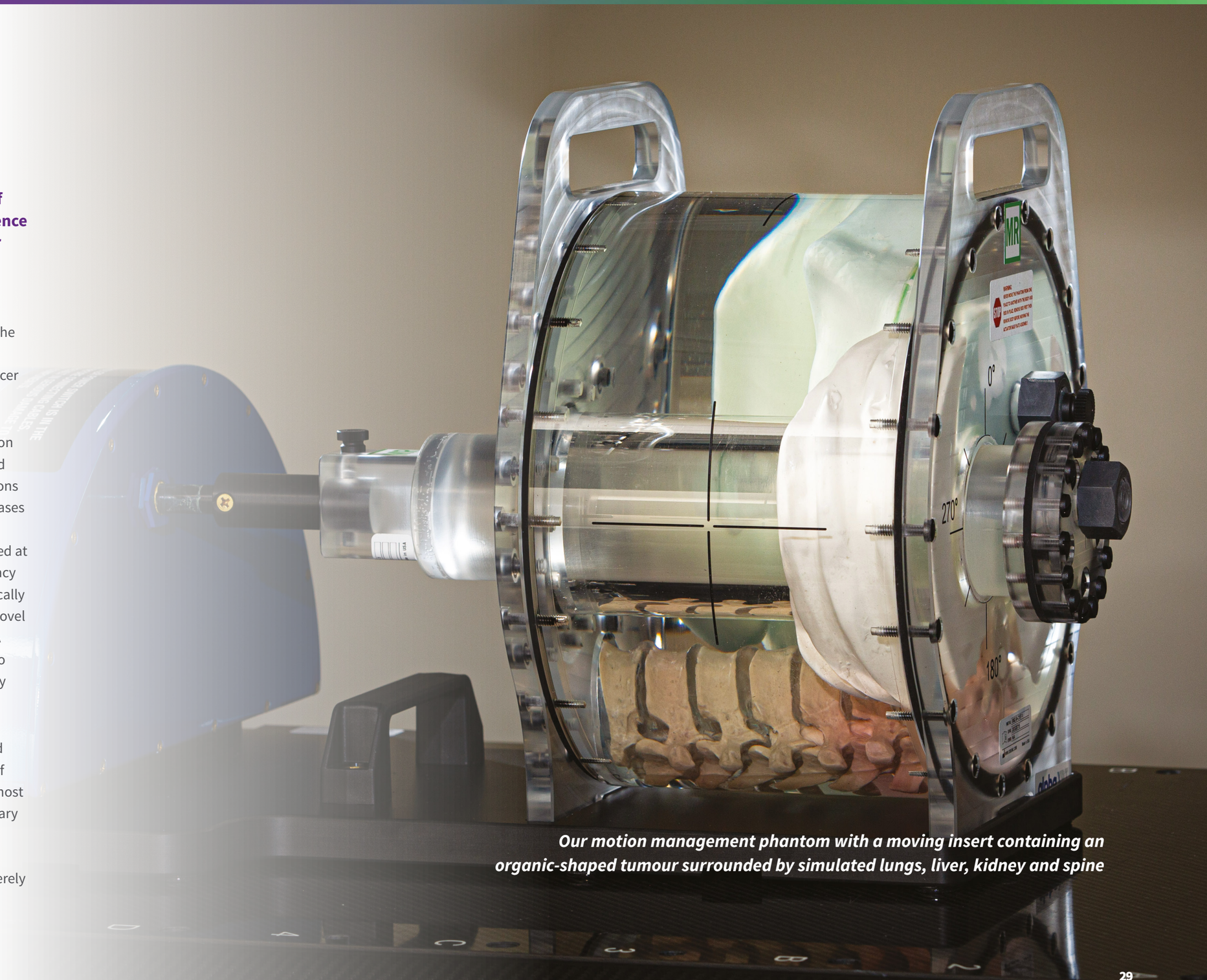
Motion management

Motion management techniques are often the standard of care in many radiation therapy departments. Using our MRI-compatible motion phantom, we are developing an end-to-end audit of this complex treatment pathway to provide confidence to the clinics in the safety and effectiveness of their 4D planning and treatment delivery.

In 2021, Alex Burton joined the ACDS as a research student working on the motion adaptive audit project. This project is the topic of Alex's PhD, which he is completing at RMIT University, and developed in collaboration with the Peter MacCallum Cancer Centre.

The process of accounting for the extent of motion in a radiation target, most commonly due to respiration, can be complex and technically challenging. This technique is often used in situations where a high degree of accuracy is necessary. The new audit cases will be available for all 4D radiotherapy delivery systems and applicable to kV and MR imaging. The research being conducted at the ACDS aims to determine a means of quantifying the accuracy of treatment delivery involving motion management in a clinically meaningful way. Development and implementation of these novel audits will use our CIRS motion management phantom – LOLA (Live On-Line Adaption). These audits will have the potential to detect inaccuracies along the planning and treatment pathway improving the safety and effectiveness of treatment delivery.

We have conducted a survey of all Australian and New Zealand radiation therapy providers to establish the current patterns of use of motion management techniques. A response rate of almost 80%, will allow us to tailor initial audit development. Preliminary analysis confirms that motion management is used by almost all clinics in the region, especially in the context of lung SABR, utilising a range of techniques and technology. The ACDS sincerely thanks all those who participated in the survey.



Our motion management phantom with a moving insert containing an organic-shaped tumour surrounded by simulated lungs, liver, kidney and spine

Audit development and research

STRATEGIC OBJECTIVES

Improving information management and data processing

The ACDS is gathering data with increasing complexity as the audit sophistication required to meet clinical need has increased. To maintain a high-quality service with software designed for more specialised treatment techniques such as SRS, SABR, and motion management, we are expanding our skilled knowledge base with software specialist Raymond Sun joining the ACDS. Our aim is to lead the development of data structures which are harmonised with international best practice.

The transfer of a facility's dose data from the planning system to the ACDS is currently a necessary but time-consuming process. However, the ACDS has a working prototype of a system designed to improve the speed and integrity of this data transfer which will significantly reduce the workload for facility staff including radiation therapists and physicists, as well as the ACDS. Currently, facility staff are required to produce documents detailing dose and plan information which is then transferred manually to the ACDS. The aim of our new software, ORCHID (Online Raymond's CHecker Integrating DICOM), is that once treatment plans are prepared, transfer of dose data to the ACDS is handled by the software and not by facility staff. ORCHID will have the capacity to extract dose information contained in the plan directly from the DICOM file, transferring it to the ACDS. This will bring the audit process more in line with the departmental workflow as planners will not be producing excess documentation typically not required for treatment delivery. Another motivation for the development of this system is to reduce the opportunity for errors due to data transfer, and to be able to more accurately assess data transferred to the ACDS by using the software, rather than manually. This will be a significant positive change to the customer experience and increase the capacity of the ACDS to analyse results.

In addition to ORCHID, ARPANSA's Project Management Advisory Group has approved project DAISY (Data Analysis and Integrated Scientific sYstem). Project DAISY will result in a purpose-built database, allowing the ACDS to store and classify data and audit results. This data can then easily be recalled, re-analysed, and used in client benchmarking and to develop research that is shared with the global community. Work on this project is progressing in collaboration with ARPANSA's Digital Technology Service.

Audit development and research

STRATEGIC OBJECTIVES

Online adaptive audit development

This adaptive audit is offered as an extension of the standard Level III audit. This audit is performed using the ACDS-modified CIRS thorax audit phantom which is designed for the Elekta Unity MR-Linac and Varian Ethos™ online adaptive radiotherapy systems. Our adaptive audits for the Ethos system are now live.

During 2020-21, 2 new audit cases based on virtual targets have been introduced for this audit. These audit cases test the currently available adaptive radiotherapy workflows required to treat the C-Series IMRT/VMAT tumour volume. The Elekta Unity's adapt-to-position workflow is tested by adapting the standard C-Series plan to treat the same volume in a physically offset phantom. The case to test the Ethos' artificial intelligence-driven adaption and Unity's adapt-to-shape workflows takes an initial plan based on a modified C-Series volume and generates an adapted plan to treat the standard C-Series volume. These adaptive audit cases use virtual targets that are provided in the planning structure set.

Further developments for this online adaptive audit, such as adaption to a CT/MR visible tumour and MR-only planning, will be conducted on our motion management phantom.

Kilovoltage therapy

Work on improving the consistency of kV treatment beam dosimetry continues, as we collect further audit data to build the ANZ dataset, allowing facilities to benchmark beam output calibration.

By the end of June 2021 we have performed 115 measurements with 26 different cones, across 12 different facilities. This benchmarking, along with recommendations for kV quality assurance from the Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) will contribute to the standardisation of dosimetry practices.

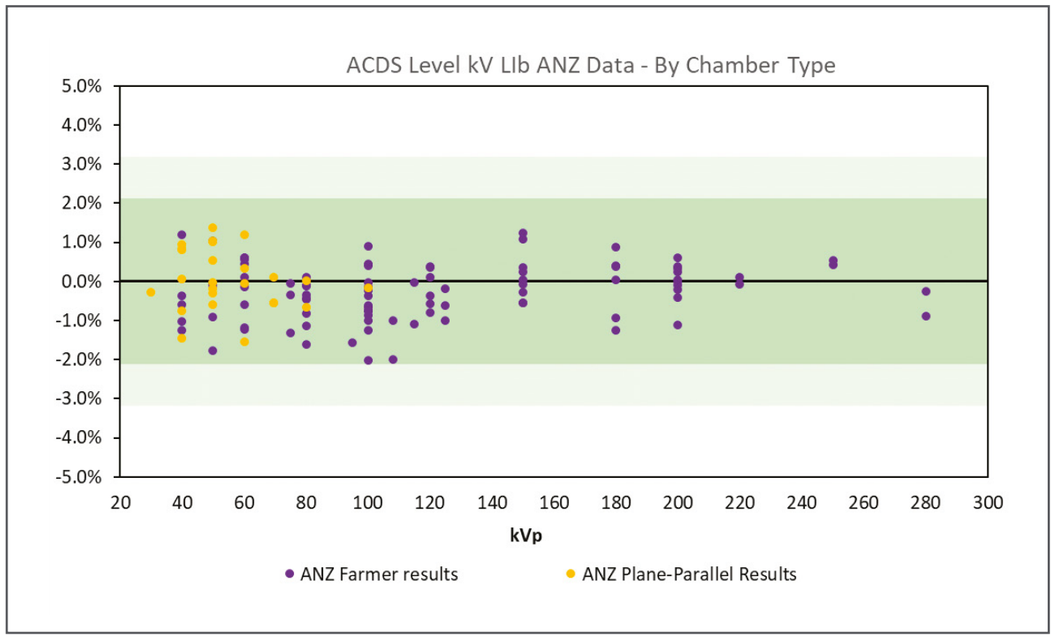


FIGURE 7

Figure 7: ANZ data for kV Level Ib reference dosimetry audits

Case studies and key findings

STRATEGIC OBJECTIVES

Sharing key findings and making recommendations for facilities provides valuable insight into ways of strengthening the quality assurance practices involved in radiotherapy planning and delivery. This in turn has a positive tangible impact on patient safety.

Volumetric modulated arc therapy (VMAT) and beam models

Collaboration between facilities, the ACDS and the CAG in response to out of tolerance results, prompted the facilities to delay introduction of a new planning system, allowing for further beam commissioning and mitigating risk for the patient community.

Two linked facilities transitioning to a new Treatment Planning System (TPS) underwent Level II audits. The outgoing TPS had been audited by the ACDS in previous years in both Level II and Level III audits. The results of the incoming TPS returned Out of Tolerance (OT) results at both facilities for both in-volume and gamma pass rate metrics.

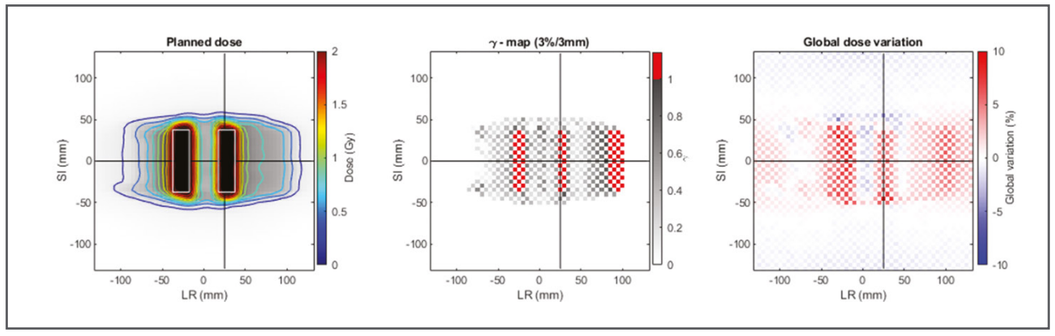


FIGURE 8

Figure 8: Coronal dose map of the Level II C-shape target volume, corresponding gamma map and global dose variation. The in-volume areas of the dose map are outlined in white on the far-left image.

The magnitude of the out of tolerance result prompted an out-of-session discussion with the CAG. The outcome of this meeting was that independent members of the ACDS team should conduct a repeat measurement at the facility that had returned the worst result of the two.

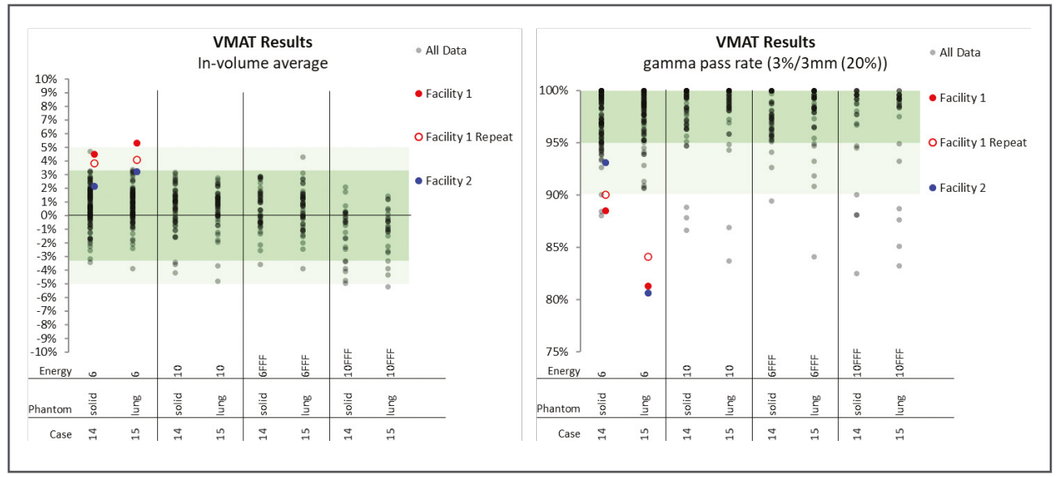


FIGURE 9

Figure 9: The ANZ data showing average in-volume dose discrepancy and gamma pass rate across all audited radiotherapy providers.

An out of tolerance audit outcome can fall into 1 of 3 categories with a graded response dependent on the audit result. These 3 categories are: resolvable immediately, requires timely follow-up, and a red flag requiring immediate intervention i.e., the potential for ceasing or limiting some treatment approaches. An IMRT/VMAT average in volume discrepancy greater than 5% is a trigger for a potential red flag outcome.

The result of the repeated measurement demonstrated a slight improvement and returned an in-volume discrepancy of less than 5%. After considering both the initial results and follow-up audit results, the facility made the clinical decision to delay transition to the new planning system until further beam commissioning had been completed. Investigations for further follow-up are being explored such as recalculation and re-analysis of ACDS-measured plans using a newer version of the beam model for the planning system under investigation as well as performing a Level III on-site audit requiring the generation of all new plans.

Case studies and key findings

Stereotactic ablative body radiotherapy (SABR) and calculation algorithms

Treatment for SABR to the spine is carefully planned to ensure that the radiation dose to nearby organs is as low as possible, while still delivering an ablative dose to the tumour. In this case study an ACDS audit demonstrated that the measured radiation dose in the phantom was higher in the spinal cord than the planning system had calculated.

During a SABR spine field trial audit of an Eclipse Acuros® XB 6FFF beam model a potential Out of Tolerance (OT) result was returned. The 50% isodose agreement in the junction between the anterior spine and the spinal cord (1D DTA) was 2.9 mm, with the measured isodose encroaching on the cord, exceeding the 1.5 mm tolerance. The gamma pass rate across the whole film returned a result of 98%. Remeasurement of the same plan returned a result of 2.7 mm confirming repeatability of the OT result.

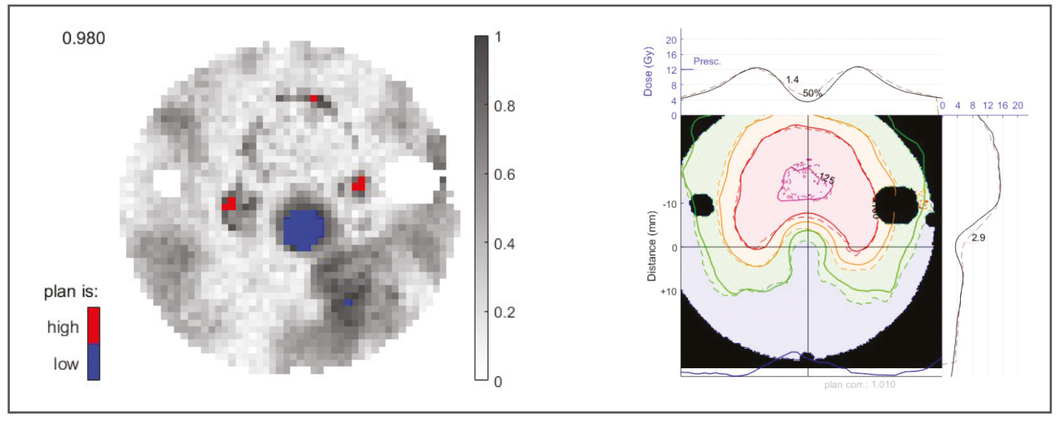


FIGURE 10

Figure 10: Demonstration of the gamma pass rate compared with the DTA of 2.9 mm

In general, the ACDS finds the Acuros® XB and Monte Carlo (MC) algorithms underestimate the planned dose in the organ at risk (OAR) volume when a planning target volume is wrapping around the OAR; in this instance contributing to the poor DTA result. At the facility's request, the spine case was re-analysed with a recalculated (not reoptimised) plan using the Monaco MC algorithm and a 1.0 mm grid spacing. The recalculated plan returned a gamma pass rate of 96.2% and 1D DTA of 1.7 mm. A new plan was recalculated and also reoptimised using the MC algorithm. Measurements of this new plan returned pass optimal results with a gamma pass rate of 98.1% and 1D DTA of 1.1 mm.

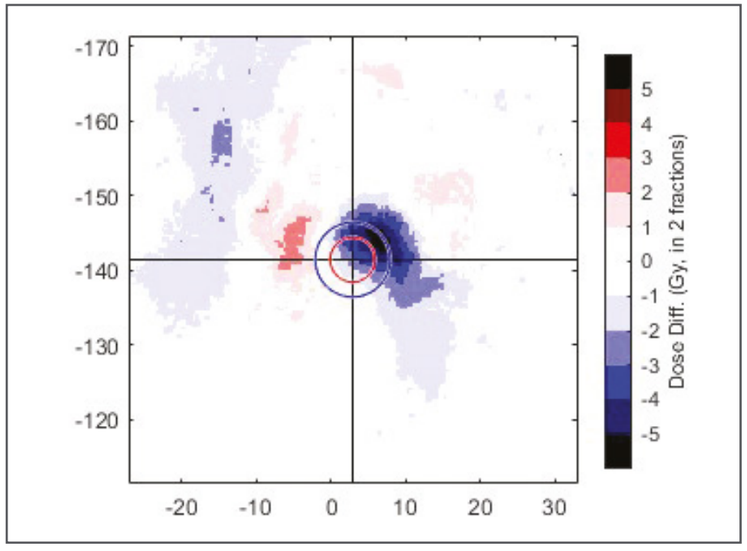


FIGURE 11

Figure 11: Dose difference map derived from the initial audit using the Eclipse Acuros® XB 6FFF beam model. Spinal cord is represented by the red inner circle and the planning risk volume is represented by the blue circle.

The dose difference map pictured in Figure 11 was derived in response to a request from the CAG to provide an estimate of the absolute dose difference in the spinal cord and planning risk volume. Figure 11 represents the difference between planned and measured dose if the complete treatment course of 24 Gy was delivered to the patient. Spinal cord is represented by the red inner circle and the planning risk volume is represented by the blue circle. Red areas on the map indicate where the plan has overestimated absorbed dose. The blue portions indicate where the plan has underestimated the absorbed dose resulting in a higher than expected dose in the phantom.

Having successfully integrated structures into a dose difference map for this scenario the ACDS are working to refine this process further. In the future, metrics can then be provided that are specific to individual structures in the treatment plan, for example spinal cord or target volumes.

Recommendations to facilities

STRATEGIC OBJECTIVES

Over the 10 years the ACDS has been auditing, we have made a total of 295 recommendations to facilities. We have addressed a total of 85 out of tolerance (OT) audit results, some of which have been resolvable immediately, with the majority requiring timely follow-up. For results where timely follow-up is recommended, ACDS audits followed up on-site are an inclusion in the subscription service.

Over time, the nature of ACDS recommendations to radiotherapy providers has changed. With the decrease in the use and commissioning of wedges to modulate fields and the introduction of audits for inverse planning modalities, (IMRT, VMAT, SABR, SRS) the ACDS have identified areas for investigation relating to treatment planning system (TPS) parameters, algorithms and overall plan quality. These recommendations aim to drive incremental improvements in the accuracy of both the planning and treatment delivery across all treatment modalities audited, improving national dosimetry and the quality of the care that our patients receive. This last financial year has seen a total of 39 recommendations.

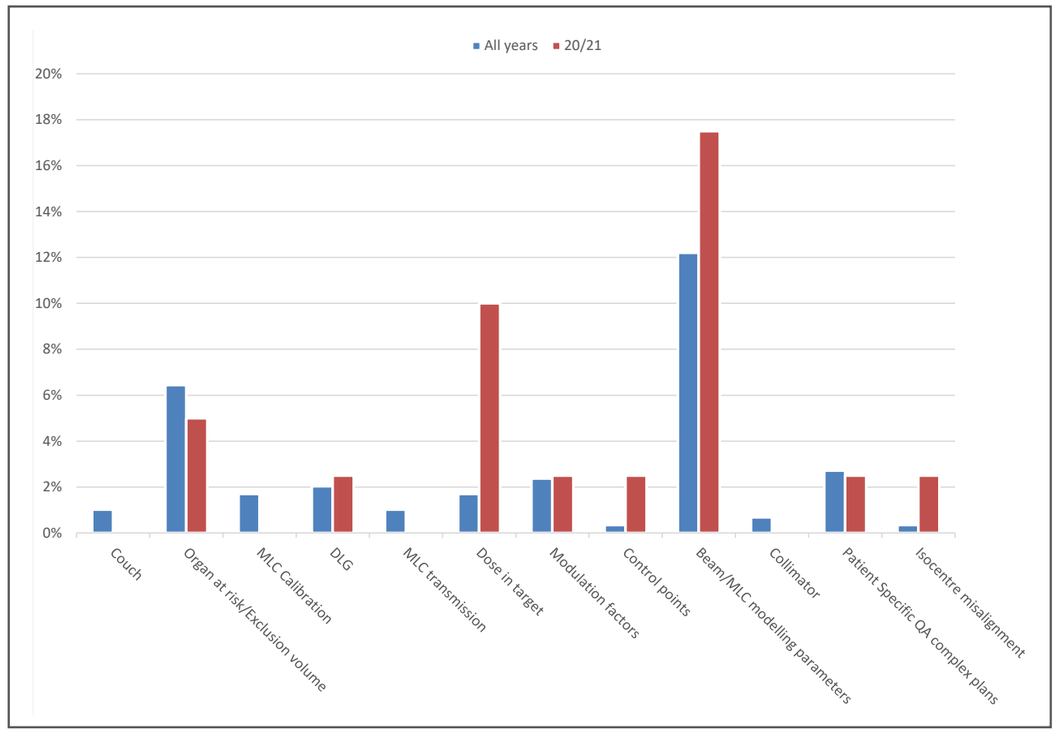


FIGURE 12

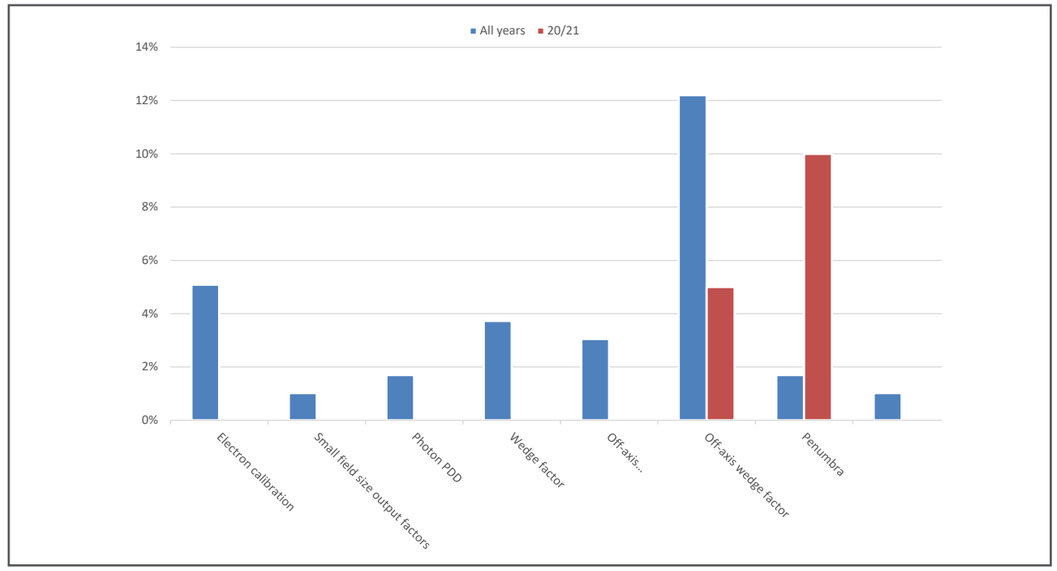


FIGURE 13

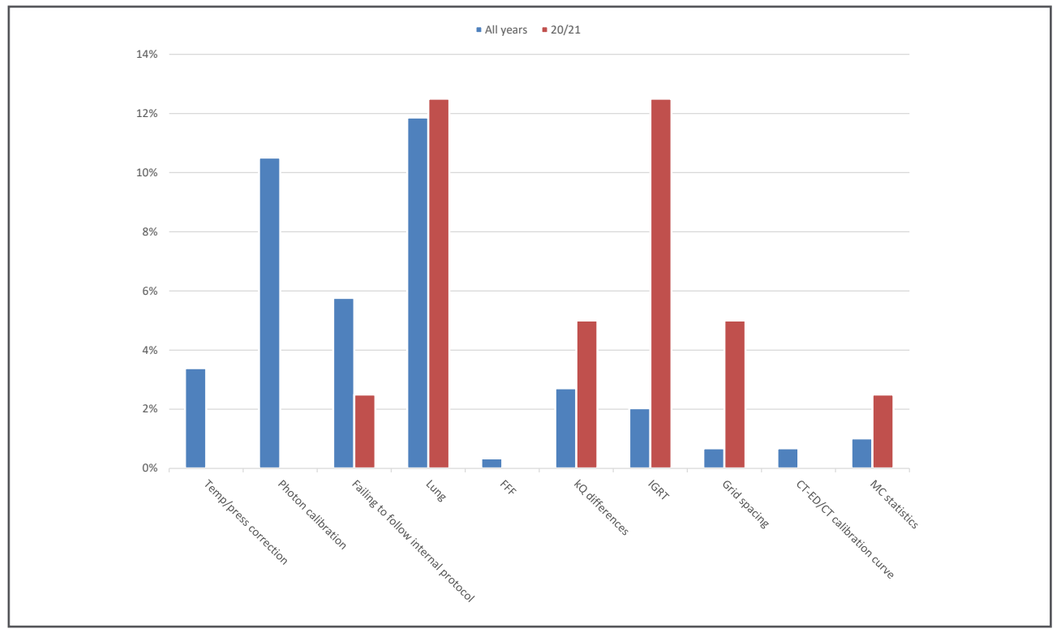


FIGURE 14

Recommendations to facilities

STRATEGIC OBJECTIVES

Acuros® XB dose calculation algorithm

The ACDS has observed a trend across many Level II audits for the Acuros® XB dose calculation algorithm where the plan has predicted a higher dose inside the field and a lower dose outside the field, than has been measured. The global dose variation across the whole array provides information in addition to the scored results, highlighting the in and out of field discrepancies as seen for the 10x10cm and 20x20cm fields shown below.

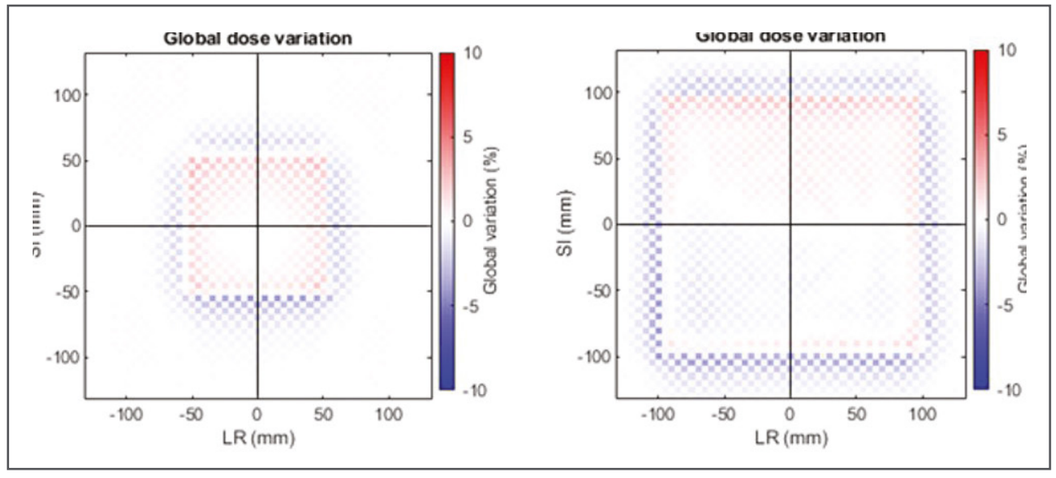


FIGURE 15

Figure 15: Global dose variation for Case 3, 10 cm field size measured at a depth of 20 cm and Case 2, 20 cm field size measured at 10 cm depth.

The metric that is scored is the local dose variation within the field, demarcated by the white square (Figure 16a). A typical observation for Acuros® XB is agreement near the central axis with increasing discrepancy towards the edges of the field. Action level points occur more noticeably towards the corners (Figure 16b); however, this discrepancy is not large enough to return an Out of Tolerance result (OT). This may not be noticed if the beam profile is only measured in the left-right and sup-inf profiles across the central axis of the field as demonstrated in Figure 18.

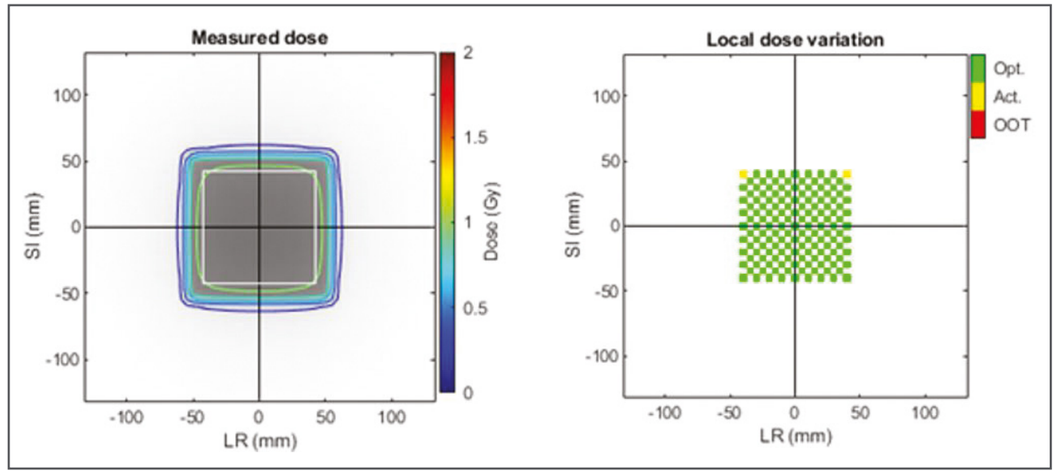


FIGURE 16a FIGURE 16b

Figure 16a: Scored infield region. Figure 16b: Scored infield data points.

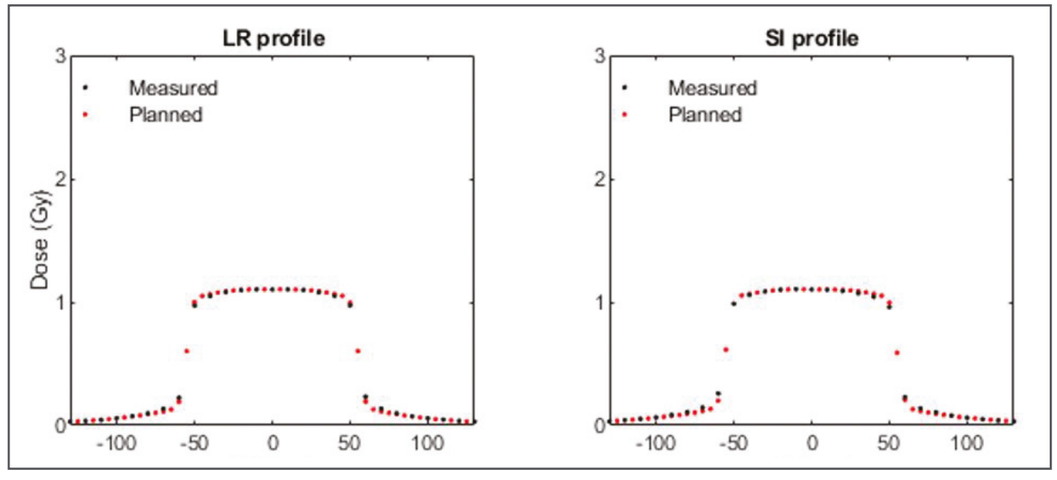


FIGURE 17

Figure 17: Lt-Rt and Sup-Inf profiles measured through the central axis of the 10x10cm field at 20cm depth.

Recommendations to facilities

STRATEGIC OBJECTIVES

The ACDS will make comment but an action level outcome will not result in a repeat on-site measurement, meaning that there is limited feedback from clinics in response to this issue. It is, however, a trend that the ACDS note consistently across multiple Acuros® XB users. This trend can be visualised through the extremes in the scored dose variation for the non-wedged and non-lung cases as shown in Figure 18.

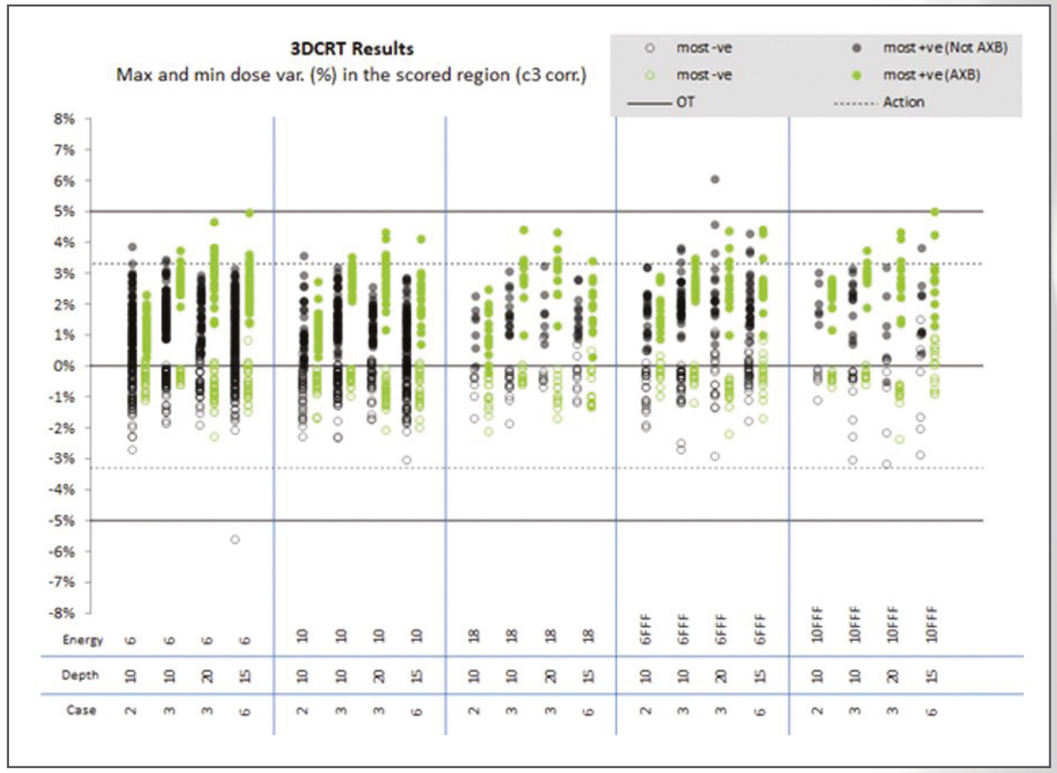


FIGURE 18

Figure 18: Dose variation inside the scored region of the 2D dose maps, at each extreme. Positive points indicate where the plan has overestimated dose. The data has been normalised to minimise the effect of the daily linac output on the result.

Recognising 10 years of ACDS audits

Well before the ACDS was officially opened at ARPANSA on 4 February 2011, many reports, investigations, events, collaborations, and commitment was seen. The initial Memorandum of Understanding was signed and executed between the Department of Health and Ageing (DoHA) and ARPANSA on 28 June 2010. Following is a brief timeline of events leading to our celebration of 10 years of ACDS audits.

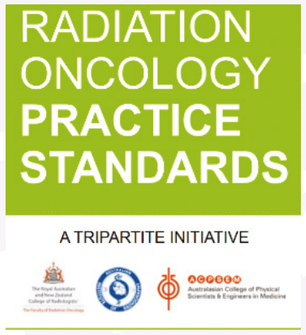
1997 Australasian College of Physical Scientists and Engineers in Medicine (ACPSEM) establishes a working party to investigate nationally coordinated quality assurance for radiation oncology.

1998 The Tripartite Committee is formed between The Royal Australian and New Zealand College of Radiologists Faculty of Radiation Oncology (RANZCR FRO), Australian Institute of Radiography (AIR) and ACPSEM.

2002 The Radiation Oncology Inquiry released the Baume report, 'A vision for radiotherapy', identifying several quality and safety issues in radiation oncology. The Radiation Oncology Jurisdictional Implementation Group (ROJIG) is established to develop a response.

2003 'Radiotherapy in Australia one year after the Baume report: vision or mirage?' recommends establishing a quality assurance program.

The Radiation Oncology Reform Implementation Committee (RORIC) was established by the Australian Health Ministers Advisory Council (AHMAC) to implement reform in the sector. The Department of Health and Ageing (DoHA) began funding RANZCR to work with the Tripartite Committee to develop radiation oncology standards.



2007 Initial draft of the Radiation Oncology Standards was submitted to DoHA.

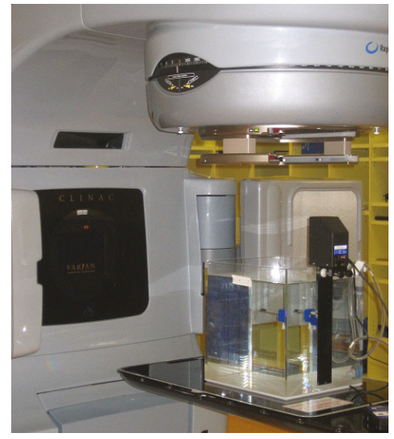
2008 The Delaney review was released in response to an incident where treatment delivery to 869 patients over a 2-year period was 5% lower than the prescribed radiation dose. DoHA approved funding to review a model for a National centre for clinical dosimetry. The review recommended the immediate creation of an Australian clinical dosimetry centre.

2010 RORIC is tasked with establishing the Australian clinical dosimetry centre. The centre becomes the Australian Clinical Dosimetry Service (ACDS) and is initially funded for 3 years and operated by ARPANSA.

In November 2010 Dr Ivan Williams commences as inaugural director of the ACDS.

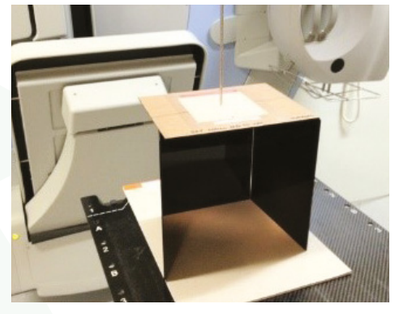
2011 On 4 February 2011 the ACDS was officially opened at ARPANSA by the Parliamentary Secretary for Health and Ageing, the Hon Catherine King MP.

On 24 June 2011 ACDS conducts its first level Ib audit.



2012 ACDS conducts field trials with Optically Stimulated Luminescence Dosimeters (OSLDs).

ACDS achieves near complete signup nationally to its voluntary audit program. It performs Level I audits on 52 linacs, 16 Level Ib audits on newly installed linacs. Just under half of all Australian linacs receive at least one audit.



2013 ACDS progress report demonstrates audit coverage exceeds targets.

Level II audits clinically deployed with 33 linac measurements completed.

KPMG releases their evaluation of the ACDS, recommending mandatory audits and continuation of the ACDS for a further three-year trial period.

2014 ACDS is endorsed and funded to continue until December 2016.

Recognising 10 years of ACDS audits

2015

The Trans-Tasman Radiation Oncology Group (TROG) requires facilities to have completed an ACDS Level I Audit prior to entering a clinical trial.

AHMAC gives in-principle support for a user-pays funding model for the ACDS.

2016

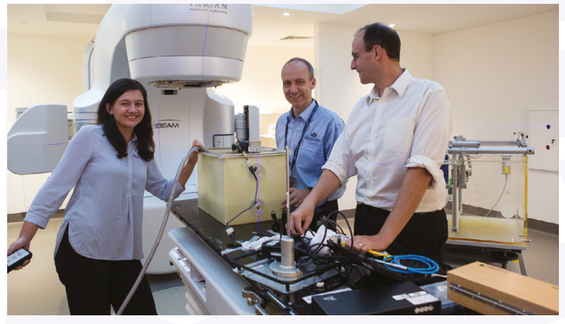
The ACDS performs its first field trial of the Level II Intensity-modulated radiation therapy (IMRT) audit.

A jurisdictional working group (JWG) is established to develop details of the user-pays proposal, to commence from 1 January 2017. The JWG 'unequivocally considered that the ACDS trial had raised the bar for quality and safety in Australia and that it would not be in the interest of the sector to retreat from these high standards.'

A review of ROHPG funding recommends all facilities be subject to a condition requiring independent dosimetry audit.

ACDS receives National Association of Testing Authorities, (NATA) accreditation for Level I, Level Ib, Level II, and Level III services.

In a world-first agreement, ACDS achieved mutual recognition of Level I audit with Imaging and Radiation Oncology Core (IROC) Houston. Level Ib and II on-site audit comparison performed at the Victorian Comprehensive Cancer Centre (VCCC).



In December 2016 ACDS funding ceases. During its first 6 years of operation, every radiation oncology facility in Australia had been audited with 142 Level I audits, 57 Level II audits, 73 Level III audits, and 69 Level Ib audits resulting in 140 recommendations to more than 70 facilities.

2017

The ACDS Oversight Committee (AOC) was established to support the transition from a free service to a 'user pays' model.

By June 46% of providers had signed up to the ACDS and a further 18% were finalising service level agreements.

In August 2017 Jessica Lye is appointed director of ACDS.

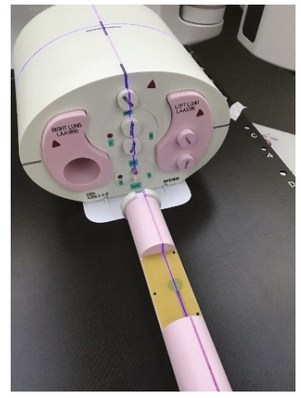
In September 2017 Level II volumetric modulated arc therapy (VMAT) audit goes live.

2018

SABR field trials commence and flattening filter free (FFF) is live in Level I OSLDs. Halcyon field trial with standard audit and Tomotherapy IMRT/VMAT is completed.

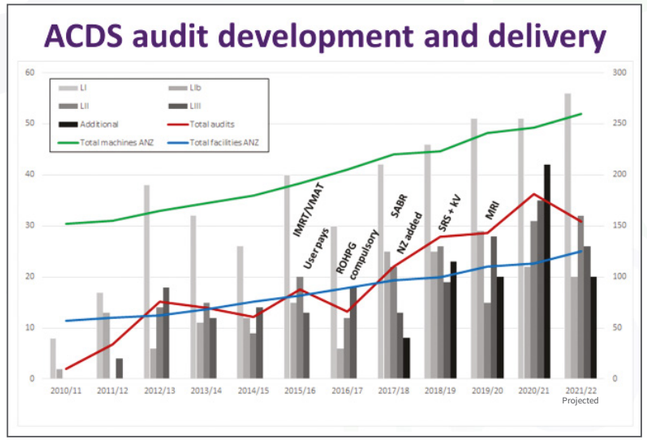
The first New Zealand audit is completed, and 3 New Zealand radiotherapy facilities sign up to the ACDS.

ACDS field trial of the cranial stereotactic radiosurgery (SRS) audit, uncovers an error resulting in an average overdose of 4.1%. The error impacted 110 patients and 122 plans and was detected due to the true end-to-end test of the patient pathway, including stabilisation. This case study is discussed in detail in the ACDS in review 2019–2020.



2020

In June 2020 Rhonda Brown is appointed director of the ACDS.



The extensive work of the ACDS continues.

More information is available on the ARPANSA website at arpansa.gov.au/acds.

Presentations and publications

STRATEGIC OBJECTIVES

Contributing to the development of the profession

RMIT Industry Day – July 2020

An overview of the ACDS
– Cate Davey

Medical Radiation Sciences Research Seminar, RMIT – May 2021

Stereotactic Ablative Radiotherapy and the challenge of measuring dose in bone
– Maddison Shaw

2020

EPSM 2020

2 November 2020
Online, Australia
Poster and presentations

How the Australian Clinical Dosimetry Service responded to COVID-19
– Ivan Williams

Monte Carlo investigation on the effect of penumbra modelling on OAR dosimetry
– Fayz Kadeer

Audit development for online adaptive radiotherapy for MRI and CBCT based systems
– Rhonda Brown

Cranial SRS phantom analytical methods used in dosimetry audits for complex treatments of multiple brain metastases
– Andrew Alves

Adaptive Radiotherapy: Setting up a Service

21 September 2020
The Christie School of Oncology UK
Poster

Lessons Learnt from a Level III Adaptive Dosimetry Audit of an Elekta Unity MR Linac
– Rhonda Brown

ESTRO 2020

28 November 2020
Online, Vienna
Presentation

Cranial SRS dosimetry audits of complex treatments of multiple brain metastases
– Maddison Shaw

2021

TROG Annual Scientific Meeting

23–24 March 2021
Online, Australia
Presentation

Updates, Collaborations and Focus for the Future
– Rhonda Brown (invited speaker)

ASMIRT appellation

In recognition of the learning and development that comes from participation in a LII or LIII ACDS audit, this is an ASMIRT-approved continuing professional development (CPD) activity for radiation therapists.

NZPEM 2021

4–5 May 2021
Online, New Zealand
Presentation

An update from the ACDS
– Rhonda Brown (invited speaker)

ASMIRT 2021

4 June 2021
Australia
Presentation

Results of SABR and SRS dosimetry audits in Australia and New Zealand
– Maddison Shaw

Publications

Shaw M, Lye J, Alves A, Hanlon M, Lehmann J, Supple J, Porumb C, Williams I, Geso M and Brown R (2021)

Measuring the dose in bone for spine stereotactic body radiotherapy
Physica Medica, 84:265-273
doi:10.1016/j.ejmp.2021.03.011

Kry SF, Lye J, Clark CH, Andratschke N, Dimitriadis A, Followill D, Howell R, Hussein M, Ishikawa M, Kito S and Kron T (2021)

Report dose-to-medium in clinical trials where available; a consensus from the global Harmonisation group to maximize consistency
Radiotherapy and Oncology, 159:106-111, doi:10.1016/j.radonc.2021.03.006

Benchmarking

STRATEGIC OBJECTIVES

One of the strengths of the ACDS is its extensive number of data points and information collected while developing, executing, and analysing ACDS audits. This data makes up the Australia and New Zealand dataset (ANZ dataset).

This comparative data is available to all subscribers, for comparison of their linac's performance with other radiotherapy departments with similar resources. This data includes 3 dimensional conformal radiotherapy (3DCRT), intensity modulated radiotherapy (IMRT), volumetric modulated arc therapy (VMAT), flattening filter free (FFF), kilovoltage (kV), small fields, stereotactic ablative body radiotherapy (SABR), stereotactic radiosurgery (SRS) and MR-Linac adaptive treatments.

Audit reports include charts of metrics such as dose variation as measured in detectors, distance to agreement – providing the opportunity to assess accuracy of treatment deliveries requiring a high degree of spatial precision – and gamma score from either film or array measurements. These metrics provide the context needed to interpret a facility's individual results.

Not only is this data valuable for comparison, but it serves to inform the development of new audits by ensuring that field trials* are robust prior to these audits being performed on-site with participating clinics. Initially, these audits are reported and not scored, but the already well-developed field trial audit provides valuable insight into the accuracy and safety of the dosimetry and treatment delivery for technology being implemented in departments

A detailed summary of the ANZ data for each audit level is publicly available on our website by searching "ACDS Australia and New Zealand datasets" or visiting arpansa.gov.au/our-services/testing-and-calibration/calibration/australian-clinical-dosimetry-service/datasets.

**A field trial is a the developmental stage of an audit. Audit development moves through three phases. From an emergent field trial, through to a mature field trial and then a live audit. An emergent field trial audit is when the technology required for performing the audit is explored in the clinical setting. Results have not been validated at this stage and tolerances are not set. An audit matures when the procedure for delivering the audit, analysing results and producing the report in a timely manner, has been refined and indicative outcomes are provided. However, an overall audit score is not returned. A field trial becomes live when there is enough data collected and experience gained such that there is confidence in the uncertainty budgets and final results are then scored. The Clinical Advisory Group (CAG) review the results of the field trials and contributes to the decision making that determines when an audit is ready to become live.*

Benchmarking

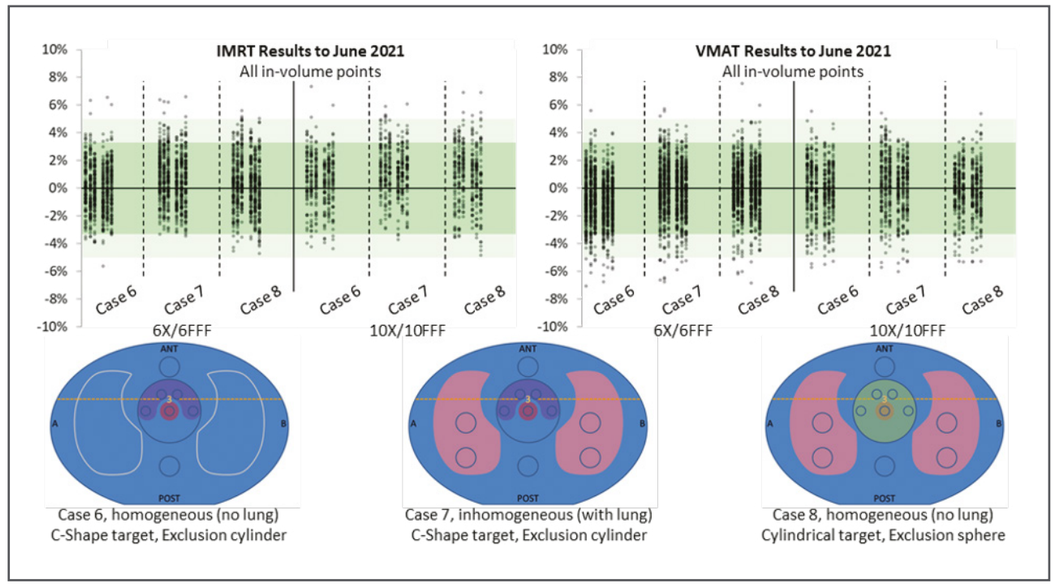


FIGURE 19

The distance to agreement (DTA) pictured below is examined SABR cases:

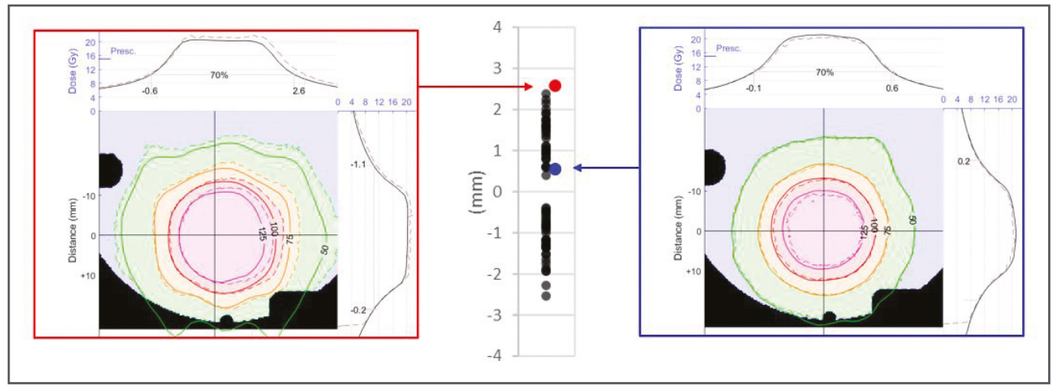


FIGURE 20

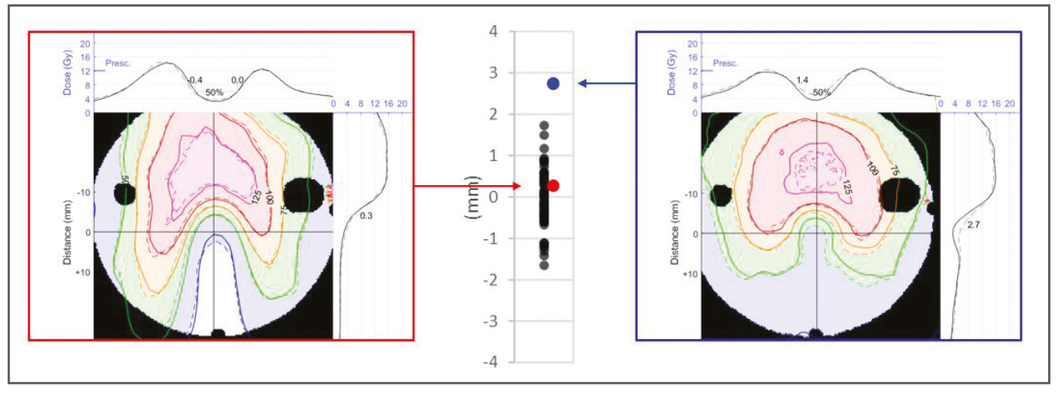


FIGURE 21

Figure 20: Case 10 is a cylindrical target in soft tissue. Both horizontal (Lt-Rt) and vertical (Ant-Post) 1D profiles are returned. The worst of four DTAs at 70% isodose is plotted for each audit. We can evaluate the spatial precision of each delivery in the context of what is routinely achieved during ACDS audits.

Figure 21: Case 11 is a spine treatment where the dose is prescribed to conform to the bone target. In this case the DTA in the Ant-Post profile at 50% isodose assesses the transition of dose from the target to the organ at risk; the spinal cord. A DTA of <1.5 mm is routinely achieved, however, some audits have failed to meet this level of precision.

Feedback

Stakeholder feedback is essential to the cycle of ACDS audit development and review. It ensures that audits continue to meet the needs of radiation therapy departments and contribute to the safety of treatment planning and delivery. The ACDS continues to actively seek feedback on both their products and service delivery.

Our post-audit feedback surveys have been redeveloped so that information is collected relative to specific professional clinical groups. This allows us to tailor our changes in practice and ensure that we provide a service reflecting the needs of our consumers. Surveys have been constructed to be as time sensitive as possible and have been implemented from 1 July 2021.

All feedback is seen as an Opportunity for Improvement (OFI) and all OFIs are discussed quarterly at the ARPANSA quality meetings or sooner when necessary. As well as informal feedback and post-audit surveys, the formal review process, developed in consultation with the CAG, is accessible via the ARPANSA website.

If a formal review is required, the facility representative is encouraged to discuss any issues or concerns with the director of the ACDS or the chief medical radiation scientist in the first instance, with the aim of a resolution via email: acds@arpansa.gov.au or phone: +61 3 9433 2220.

Alternatively, or in addition to this, there is the opportunity to either:

- request a further audit review
- dispute a review response by CAG
- provide feedback or a complaint.

Australian Clinical Dosimetry Service

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