Catalan Clinical Audit
Network for Quality Improvement
in Radiotherapy

Dosimetry audit CAT-ClinART

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2014…

Quality assurance

Multicentre validation of IMRT pre-treatment verification: Comparison of in-house and external audit

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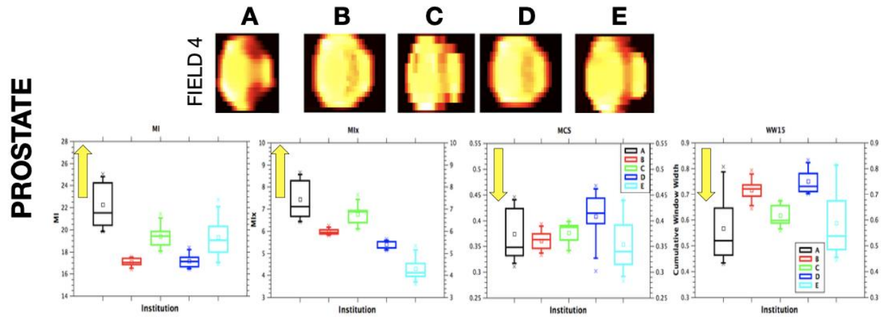

2017…

VMAT planning

Multi-centre audit of VMAT planning and pre-treatment verification

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	No. of arcs	Centre	PQI	MU	Beam on time (s)	BI	MCS	MIt	TotalRRvar (MU/min)	TotalGSvar (deg/s)
Prostate	1	A	5,13	487	74,6	7,6	0,24	0,62	579,6	0,0
		B	5,08	448	74,6	5,7	0,28	0,64	824,4	0,0
		C	5,22	552	74,6	7,3	0,21	0,84	730,8	0,0
		D	4,71	574	78,7	14,9	0,24	0,88	1483,2	7,2
		E	4,47	528	74,6	7,1	0,22	0,66	363,6	0,0
		F	4,54	379	63,4	3,0	0,52	0,87	10461,6	54,0
		G	4,41	545	74,6	7,6	0,24	0,72	759,6	0,0
		H	4,37	684	136,7	11,9	0,24	0,72	0,0	3,6
		I	5,21	560	75,2	10,5	0,26	0,68	1490,4	3,6
Prostate	2	A	5,48	483	149,2	7,3	0,22	0,58	367,2	0,0
		B	5,41	522	149,2	6,7	0,23	0,69	612,0	0,0
		C	5,40	600	149,2	8,7	0,18	0,80	648,0	0,0
		D	5,26	630	149,6	14,7	0,22	0,85	2534,4	0,0
		E	4,62	545	149,2	7,2	0,21	0,61	518,4	0,0
		F	4,80	483	121,3	3,3	0,48	0,76	11066,4	14,4
		G	4,73	561	149,2	7,7	0,23	0,66	813,6	0,0
		H	5,07	654	151,4	13,8	0,24	0,70	705,6	7,2
		I	5,41	508	149,2	10,2	0,27	0,56	2210,4	0,0

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SUMMARY

1. Beam Output Audit (dose under reference conditions).
2. Measurements/Additional QA.
3. TPS Data Collection.
4. Complex Dosimetry Check: End 2 End.
5. Mock patients: Contouring, Prescription and Planning.

0. CONTEXT: EUROPE

- 2013/59/EURATOM
  - *"clinical audits are carried out in accordance with national procedures (58e)"*
  - *"ensure that the undertaking implements appropriate quality-assurance programmes and … verification of administered dose"*

Dose calibration cGy/UM **Beam Output Audit**

- France (ANSM).. mandatory external QC audits..
- Germany, Italy, Spain…

1. BEAM OUTPUT AUDIT: SPAIN

- NO national level auditing body.
- Required for clinical trials

EORTC

IROC – MDAnderson. (Information on setting up an audit with IROC, if required, can be found here.)

PTW-Freiburg/MTK-Schein-Germany

BELdART/BHPA-Belgium

IAEA -Eastern Europe

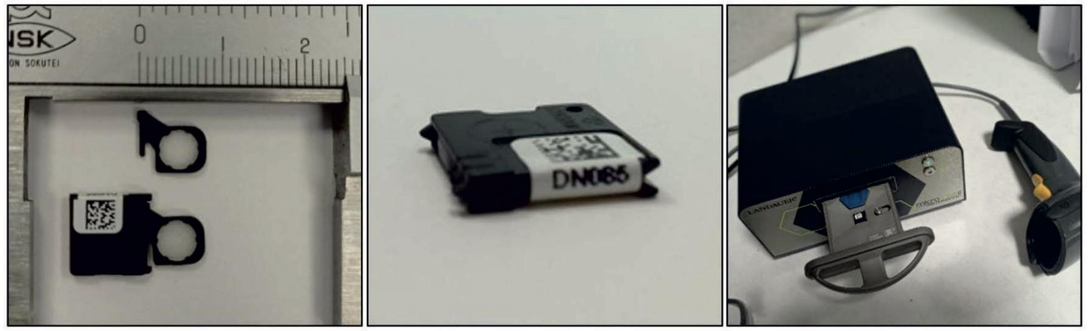
IPEM-UK (host/visitor cross-check audits)

NCS Audit-The Netherlands

However, it is not mandatory to send an audit from one of these institutions: if a document satisfies all of the criteria detailed in the previous section it will always be evaluated and could be accepted even if the auditing institution is, for example, the Physics department of a neighboring hospital.

1. BEAM OUTPUT AUDIT: SPAIN

- NO national level auditing body.
- Successful pilot studies by “Centro Nacional de Dosimetria”:
  - Based on OSLD nanoDot (Landauer).



Pilot study of a postal dosimetric audit for radiotherapy in reference conditions

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Fecha de Recepción: 22/02/2022 - Fecha de Aceptación: 23/03/2022

LANDAUER®

URGENT – Medical Device Recall- Response Required

nanoDot™ Dosimeter (For Use in Radiation Therapy and Diagnostic Imaging)

July 27, 2023

Update to July 12, 2023 Recall Notice

Reason for the Voluntary Recall: LANDAUER received reports indicating that some nanoDots may potentially be outside the specified range of +/-5.5% accuracy. LANDAUER is conducting an ongoing investigation of nanoDots and has identified a potential issue in the manufacturing process. LANDAUER has included the General Purpose (+/-10%) nanoDots distributed to medical customers in the scope of this recall out of an abundance of caution.

1. BEAM OUTPUT AUDIT: CAT-ClinART

- Set-up a “first” and ”local” auditing body.
- No passive detectors.
- Auditing equipment (QUATRO-like): 1 eletrometer, 2 Farmer-type ionization chambers, thermometer/barometer. (TRS-398)

Owned or loan?

- 1 reference center
- Periodic intercomparisons at reference center
- Water tank from audited center.
- Set-up by auditor
- Energies used for prostate treatments. (Others upon request).

2. MEASUREMENTS/ADDITIONAL QA

IROC®
IMAGING AND RADIATION ONCOLOGY CORE
Global Leaders in Clinical Trial Quality Assurance

Institution: _____
Machine: _____

Annual Chec

Dosimetry
Full calibratio
Documentatic
Output factor
Output factor
CAX PDD/TM
Physical Wed
Dyn./ Virt./ Ur
Tray factors..
Monitor unit li
X-ray output
X-ray and ele
X-ray and ele
X-ray flatness
X-ray symme
Electron flatn
Electron symi
SRS arc rotat
MLC transmis

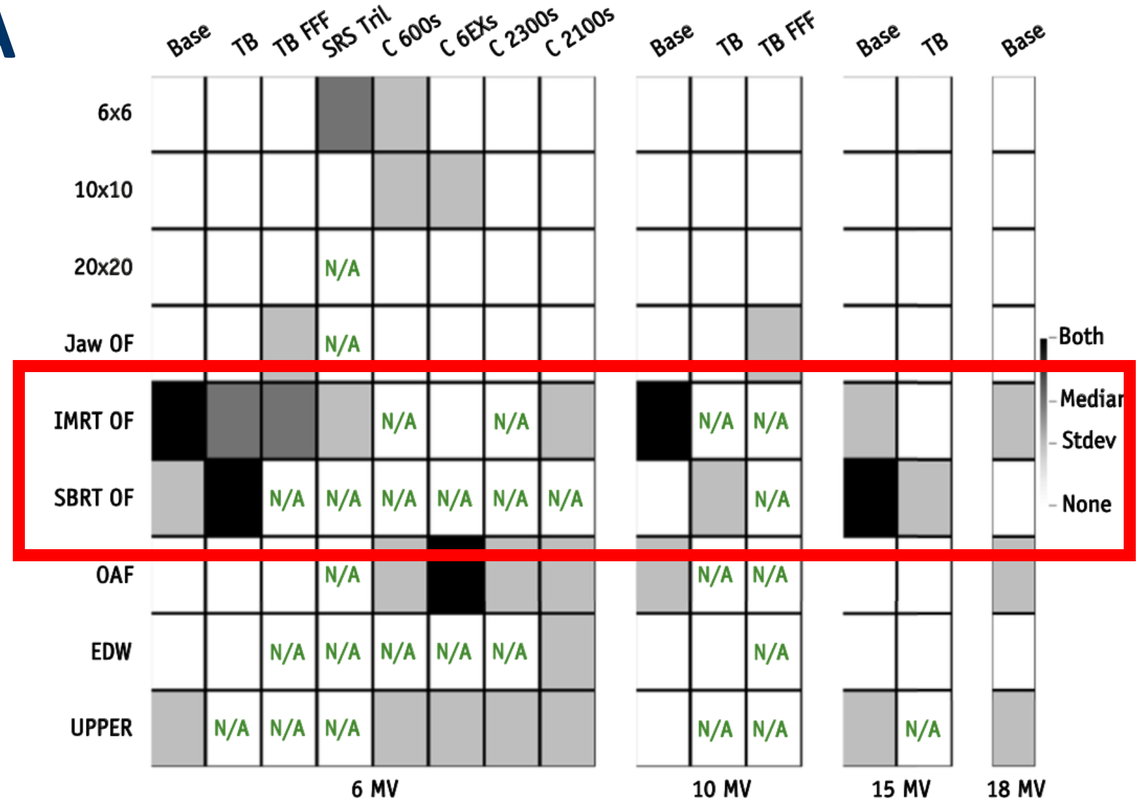
Mechanical
Collimator rot
Gantry rotatic
Couch rotatio
Coincidence
Coincidence
Tabletop sag
Tabletop ang
Table travel .
Stereotactic a
MLC leaf pos
MLC spoke s
Coincidence
Segmental IM
Moving windc

Table 1 The 15 most common deficiencies (eg, ≥4% calibration error or ≥3% relative dosimetry error) noted during IROC Houston on-site visits, including the frequency by institution and by linear accelerator (linac)

Deficiency observed	Institutions with deficiency, n (%)	Linacs with deficiency, n (%)
TG-40 & TG-142 compliance	337 (82)	-
Small-field output factors*	132 (59)	165 (51)
Wedge factor (incl. field size/depth dep.)	134 (33)	171 (17)
Off-axis factor	87 (21)	109 (11)
Electron calibration	83 (20)	105 (10)
Photon PDD	75 (18)	100 (10)
Using outdated calibration protocol (TG-21)	70 (17)	-
Electron PDD	47 (12)	57 (6)
Temperature/pressure	44 (11)	-
IGRT isocenter coincidence*	3 (9)	4 (8)
Beam symmetry	34 (8)	44 (4)
Photon calibration	32 (8)	34 (3)
Brachytherapy source calibration*	17 (7)	-
Electron cone factor*	18 (6)	19 (5)
Output factor (not "small field")	21 (5)	24 (2)

Abbreviations: IGRT = image guided radiation therapy; IROC Houston = Imaging and Radiation Oncology Core Quality Assurance Center in Houston; PDD = percent depth dose; TG = Task Group.

Values are shown as a percentage of institutions or linacs that received each test, which was typically all 409 institutions and 1020 linacs. However, not all institutions received all tests (eg, as the test suite evolved, and based on the equipment of the institution); tests where this occurred are denoted with an *. The least sampled test was IGRT isocenter coincidence, evaluated at 32 institutions (50 linacs).



Kerns, et. al 2016

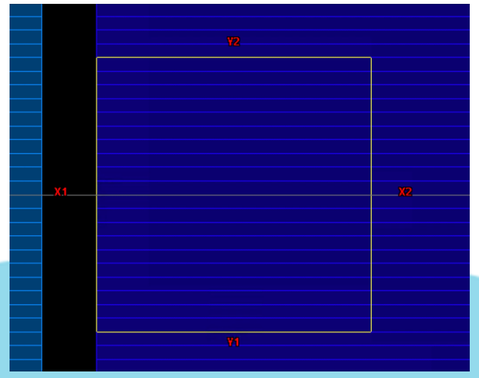
common. Small field output factors (particularly those defined by the MLC) have previously been shown to be poorly calculated by the TPS (4, 5) and were found to be the most common overall dosimetric failure (59% of the institutions had a result outside of tolerance). However,

Kry, et. al 2017

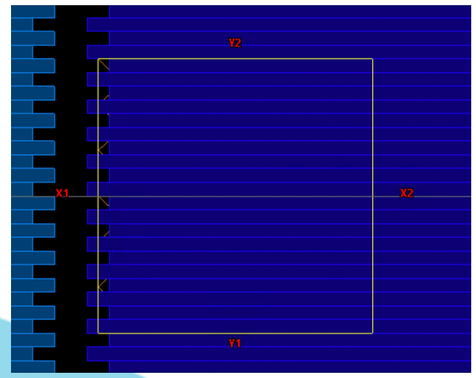
2. MEASUREMENTS

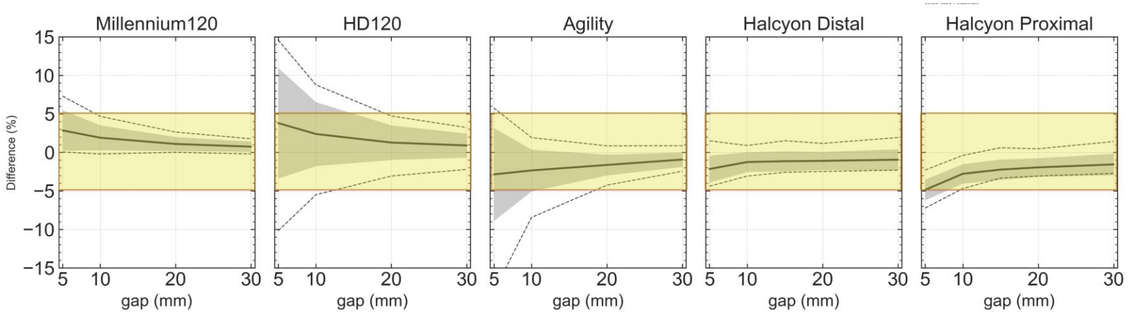
- 10 cm x 10 cm, SSD 90 cm, 10 cm
- TPR20/10
- Mechanical QA: Not included.
- Output Factors: not included.
- MLC tests (SGs+aSGs). (Saez et. al, 2023)

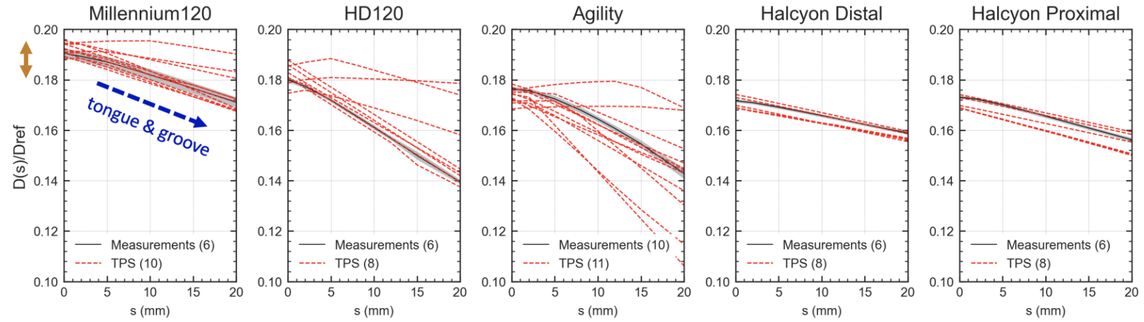
Sweeping gaps*
(5, 10, 20, 30 mm)

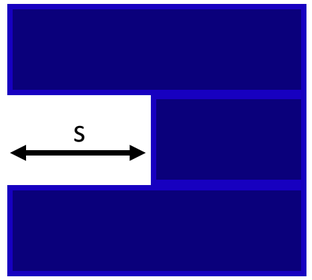


aSynchronous sweeping gaps*
gap 20 and s = 0, 2, …, 20 mm









To be included in UK and IAEA audits!

*Hernandez, V., **Commissioning of the tongue-and-groove modelling in treatment planning systems: from static fields to VMAT treatments,** Phys. Med. Biol. **62** (2017) 6688–6707

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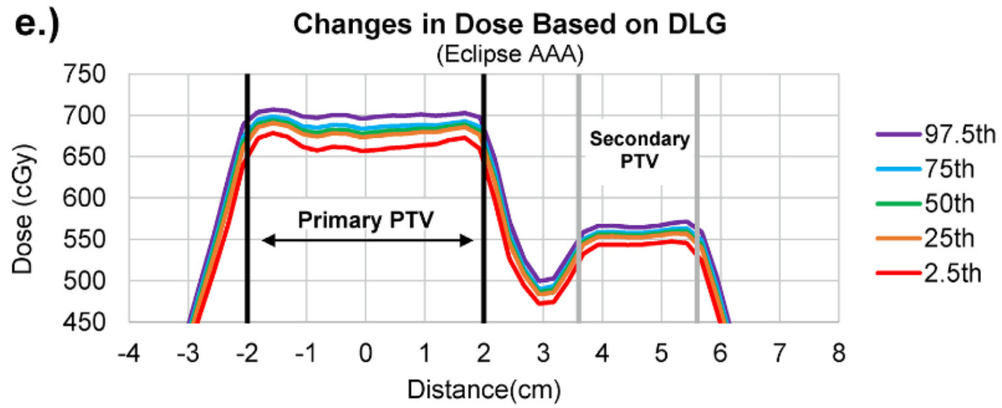
3. TPS DATA COLLECTION

- 10 cm x 10 cm, SSD 90 cm, 10 cm
- TPR20/10
- MLC tests (SGs+aSGs). (Saez et. al, 2023)

DICOM objects from the TPS BeamParameters

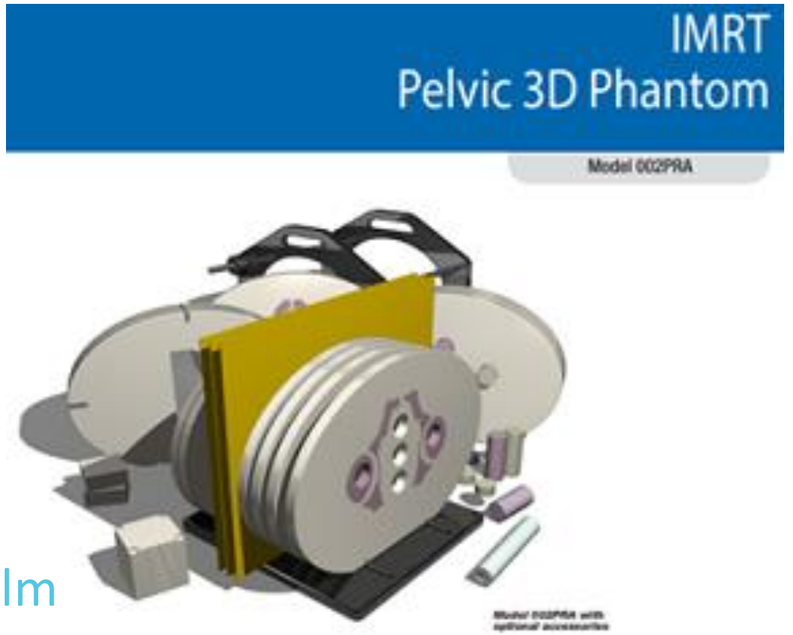
Why?

- Most IROC phantom failures are due to calculation errors (Kerns et al, 2016)
- Atypical TPS beam modeling parameters are associated with failing phantom audits (Glenn et al, 2022; Glenn et al, 2020)



Independent recalculation

4. End 2 End (Complex Dosimetry Check)



- Prostate case + anthropomorphic phantom.
- Common structures & prescription.

DOSE AUDIT:

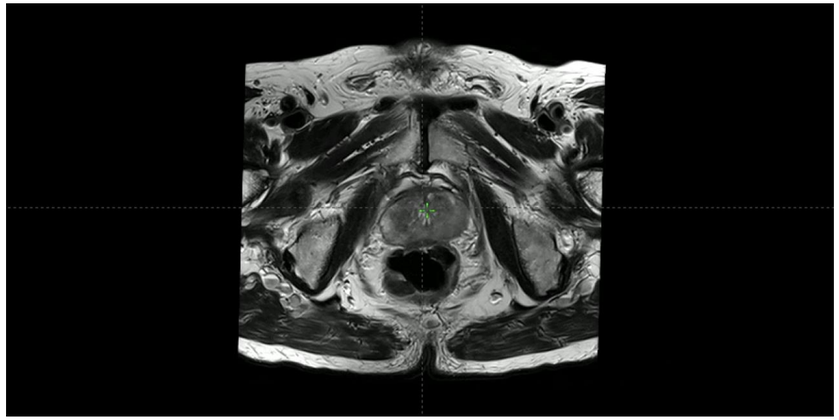
- Local PSQA (± secondary calc).
- 10 cm x 10 cm on local QA device. Opt: local chamber ± local film
- Dose measurement with ionization chamber (McKenzie, 2014).
- Radiochromic film + dosimetry (HSCSP + HCB (redundant))

(Beveridge et al, 2024).

- Plan analysis comparison (Jurado-Bruggeman et al, 2017; Hernandez et al 2018)

5. Mock prostate patients

- **2** clinical cases (based on real patients) with a full clinical profile:
  - Previous medical history, symptoms, CT, RM, …



  - Each participating site:

- Treatment decision: targets,
- Dose prescription,
- Organs at risk goals.

5. Mock prostate patients: Analysis

Geometric

Mètrica
DSC (Dice Similarity Coefficient)
sDSC (Surface Dice, τ = 3 mm)
MDA (Mean Distance to Agreement)
HD95 (95th Percentile Hausdorff Distance)
Variació del volum

- Treatment decision: targets,
- Dose prescription,
- Organs at risk goals.

Dosimetric

- Targets: coverage, homogeneity
- EUD for OARs
- Evaluation on the ’majority class’

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