Patient Specific Quality Assurance in IMRT

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What are Differences in Patient Specific QA Between 3D-CRT and IMRT?

Outline

Patient Setup
↓
Patient Immobilization
↓
Treatment Planning
↓
Treatment Verification
↓
Dose Verifications

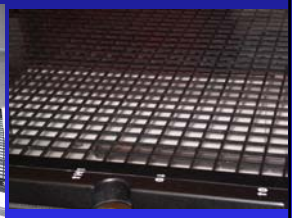
Patient Setup and Immobilization

- Setup patient in a comfortable position.
- Immobilize patient well.
- Carefully screen patients for suitability of IMRT treatment.

Patient Setup

Comfortable patient positioning

Index Patient Positioning

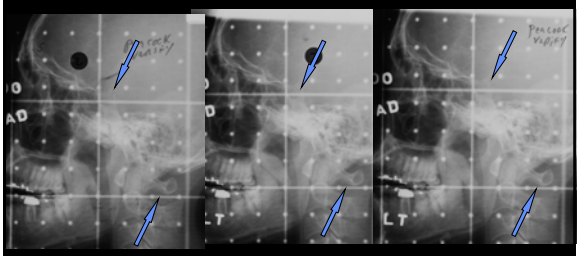


More Beam Accessibility

Patient Selection

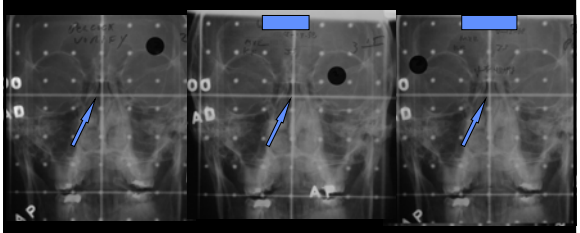
- Weekly conference to discuss potential patients for IMRT treatment, based on available machine time and man-powers.
- Compare conventional 3D plans with IMRT plans for justification of applying IMRT in new treatment sites.
- Patients who can not sustain prolonged treatment time are not qualified for IMRT.

Three Sets of Orthogonal Films



0 Minutes 15 Minutes later 30 Minutes later

Three Sets of Orthogonal Films

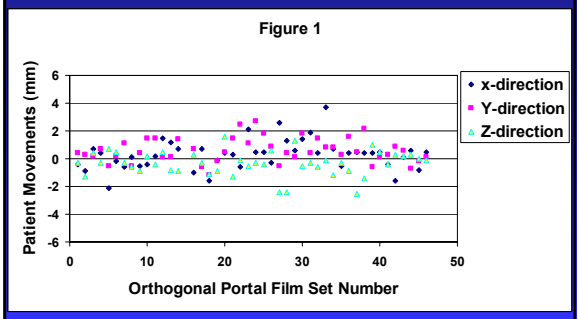


0 Minutes 15 Minutes later 30 Minutes later

How Much Patient Moved ?

- 16 patients were participated in this study.
- Taking orthogonal portal films prior to and after treatment for the first three days.
- These portal films are digitized and analyzed by a physician and a physicist.

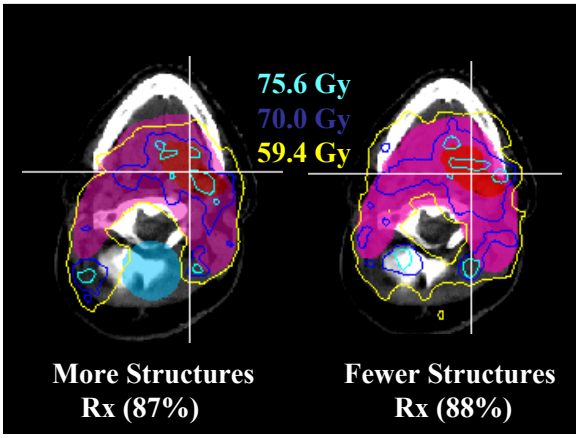
Patient Movement



Treatment Planning

Target and Structure Delineations

- Only treat contoured targets
- Only spare contoured structures
  Spinal Cord, Brain stem,
  Optical structures, Parotid glands
  Mandible, Tongue, TMJs, Larynx
  Ears, Neck skin, artificial structures
  if needed.



Plan Acceptance Criteria

- RTOG Protocols (www.rtog.org)
  H0022 - T1-2 Oropharyngeal Cancer
  H0225 – T1-4 Nasopharyngeal Cancer
- Establish local standard for each disease site by periodically reviewing approved plans.

T1-2 Nasopharyngeal Cancer

Structures	Max. Dose (Gy)	Dose to 5% Vol. (Gy)	Dose to 10% Vol. (Gy)
Chiasm	27.5	21.5	19.7
Spinal Cord	38.3	30.6	25.8
Brain Stem	50.9	40.4	37.6
Optic Nerve	23.7	22.2	18.8
Eye	25	13.5	9.8
	Mean Dose (Gy)	Dose to 50% Vol. (Gy)	Dose to 80% Vol. (Gy)
Parotid Gland	26.8	25.1	17.9
T-M joint	33.8	30.5	26.7
Mid./Inner Ear	41.4	38.3	31.3

T3-4 Nasopharyngeal Cancer

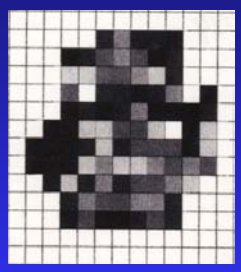
Structures	Max Dose (Gy)	Dose to 5% Vol. (Gy)	Dose to 10% Vol. (Gy)
Chiasm	42.7	36.4	34.2
Spinal Cord	42.2	33.0	26.7
Brain Stem	55.3	43.1	40.0
Optic Nerve	41.6	34.4	31.6
Eye	32.8	21.9	19.6
	Mean Dose (Gy)	Dose to 50% Vol. (Gy)	Dose to 80% Vol. (Gy)
Parotid Gland	27.8	24.6	18.7
T-M joint	38	36.7	31.5
Middle/Inner Ear	49.6	49.8	42.2

Treatment Verification

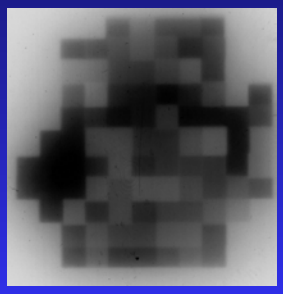
Verification

- Iso-center verification - Orthogonal films
- Check intensity pattern prior or during treatment
  - Use portal film with reduced dose.
  - Use new extended dose range film (EDR2) tapped in a reticule.
  - Use Computed Radiography (CR).
- Check delivered MU/field vs planned MU

Intensity Pattern Check

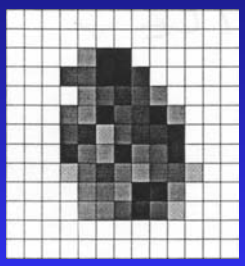


Print Out

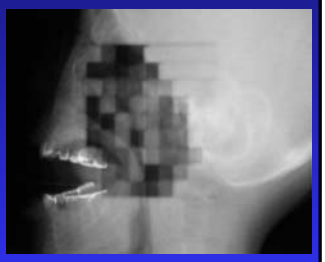


EDR Film

Intensity Map



Port Film



What is Computed Radiography?

- A digital replacement for x-ray film and film processors

film ⟶ phosphor screen

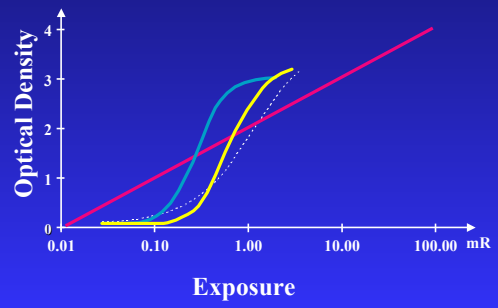
cassette ⟶ cassette

processor ⟶ scanner

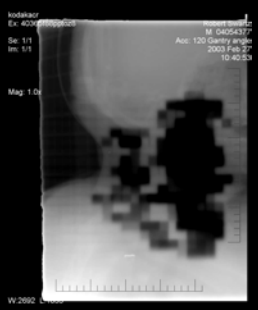
Computed Radiography System

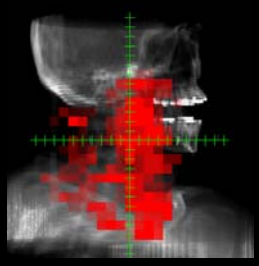
Computed Radiography System

Exposure Latitude



Intensity Pattern Check





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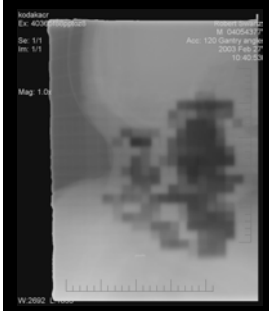
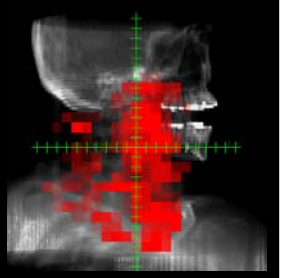




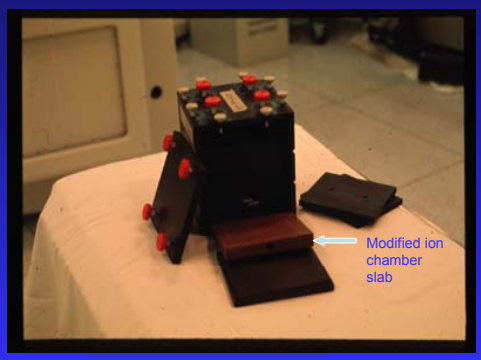
Dose Verification

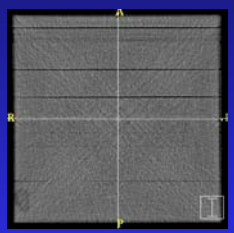
Dosimetric QA

- Delivery a patient specific phantom plan is a good dry run to test connectivity of the entire IMRT procedure from planning to delivery.
- Identify undeliverable beams, potential collisions and obstructs in the beam.
- Verify entire plan, not single beam, including the same beam geometry as in the patient plan.
- It is difficult to find a uniform dose region within a single beam, especially for complex H&N plans

Useful Tools

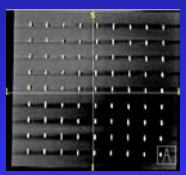
- Phantoms (Various sizes)
- Small ion chamber – (CC-13, Wellhoffer, 0.13 cc active volume).
- Electrometer
- TLDs (TLD reader)
- EDR2 film (film scanner, analysis software)
- MOFETs (optional)
- MapCHECK (optional)





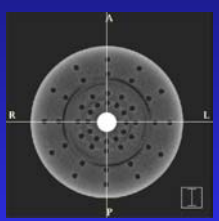
(a)

(b)



(c)

(a)



(b)

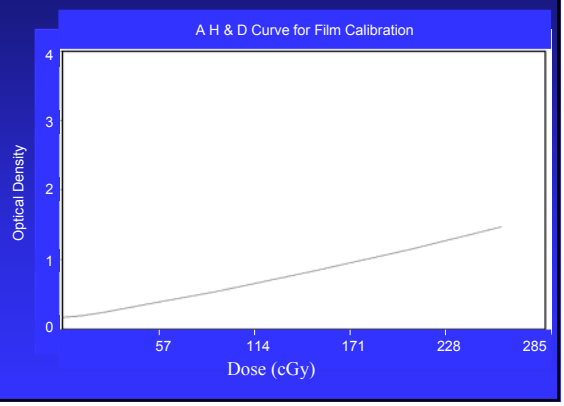
MapCHECK™

Solid state circuitry in an acrylic housing, with the 445 diode detectors

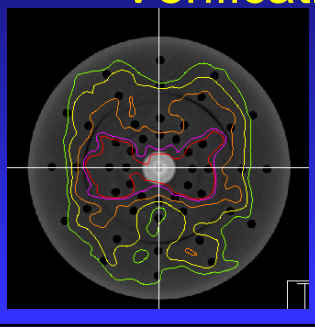
Extended Dose Range film (EDR2)

Strip Numbe	MU	Dose (Gy)
1	1x3	10.8
2	5x3	21.9
3	10x3	36.9
4	20x3	63.8
5	30x3	91.3
6	50x3	150.0
7	70x3	208.6
8	90x3	264.0

100 SSD, 3 cm depth

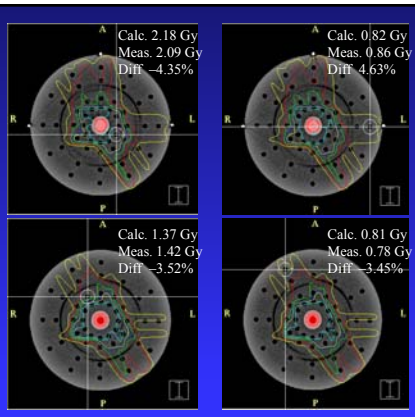


Multiple Point Dose Verification

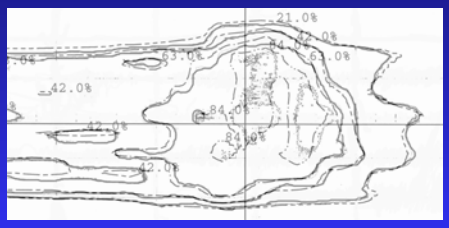


Ion chamber

MOSFETs – Similar to diode detector

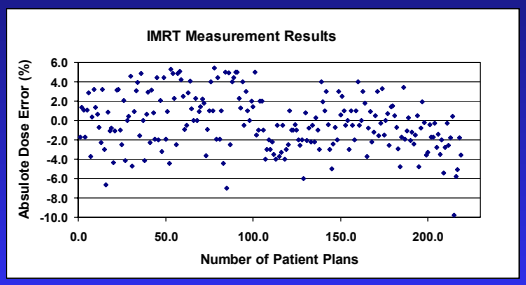


MLC Plan Isodose Verification

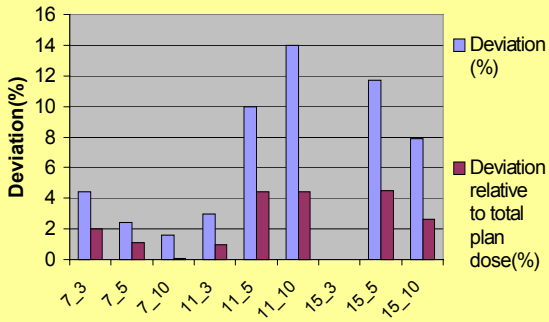


0.40 Gy, 0.30 Gy, 0.20 Gy, 0.10 Gy

Point Dose Verification



Deviation between measured dose and planned dose at low dose regions



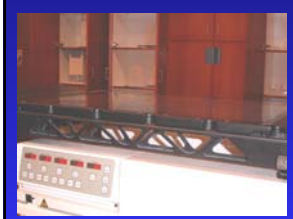
Dose Verification Acceptance Criteria

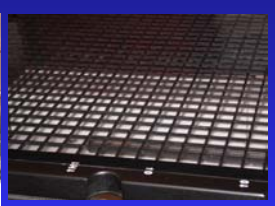
- For high dose regions (>80%), less than 5% discrepancy between the measured and calculated doses
- For low dose regions (30~ 50%), less than 5% discrepancy between the measured and calculated doses when both normalize to the maximum dose.

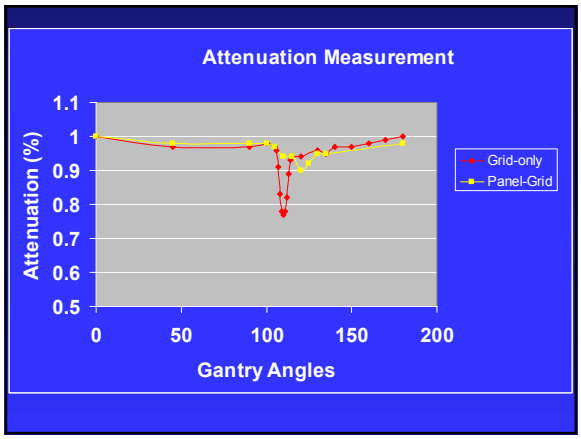
Table Attenuation

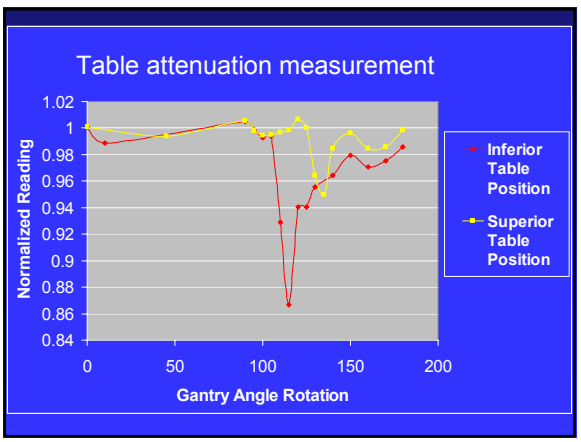
- IMRT requires more beam angles than conventional treatment to achieve high conformity in dose distributions.
- Carbon fiber tabletop can reduce beam attenuation but the attenuation may vary depending on the thickness of materials.

Conforming Tabletop









Special Clinical Problems- Skin Dose Problem

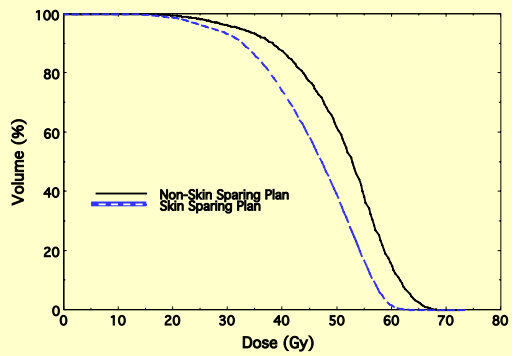
Patient with remarked skin reaction

Patient Skin Dose Problem

- Multiple tangential beams decrease skin sparing
- Bolus effect, due to the use of the head-shoulder mask, increases skin dose about 15% when compared with and w/o the head- shoulder mask
- In order to cover superficial nodes, the inverse planning system increases beam intensity on the neck skin
- Contour neck skin as a sensitive structure to avoid the high dose on the neck skin

Skin Dose Investigation

	Opp. Lateral		IMRT w/ skin included		IMRT w /skin excluded		IMRT w/skin excluded + skin spare	
	w/ mask	w/o mask	w/ mask	w/o mask	w /mask	w/o mask	w/ mask	w/o mask
Ave. Daily dose (Gy)	1.53 ± 0.39	1.31 ± 0.31	1.82 ±0.13	1.66 ± 0.15	1.53 ±0.16	1.25 ±0.17	1.44 ±0.12	1.17 ±0.10
Ave. Total dose (Gy)	50.63	43.12	60.10	54.64	50.34	41.10	47.54	38.70



Summary of Patient Specific QA

- Patient setup and immobilization
- Treatment plan QA
- Treatment Verification (Iso-center, intensity map check, and delivered MU)
- Dose Verification
- Special clinical problems