

Establishment of the Medical Physics Team and its Work at Osaka University Hospital (OUH)



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Medical Physicist (MP) at Osaka Univ. Hp. (OUH)

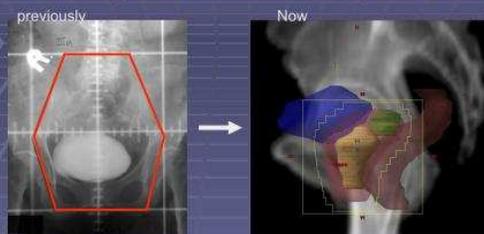
- Necessity & Japanese situation
 - Advanced radiotherapy growing up & up
 - Rare existence of MP in Japan
 - Start-up of Div. of MP in Osaka Univ. Hp.
- Role of MP
 - Chasing Accuracy & Precision
 - Quality Assurance (QA) & Quality Control (QC)
 - Radiotherapy Planning
 - as one of radiation oncology staffs
- Research Work

Treatment Modalities in Osaka Univ. Hp. (OUH)

① External Beam RT



Change of Radiotherapy (RTx)



- | | |
|---|---|
| <ul style="list-style-type: none"> ▪ 2D Planning ▪ Plain X-ray photo ▪ Field drawn by line | <ul style="list-style-type: none"> ▪ 3D Planning ▪ CT & Computer-Assisted ▪ Irradiated Target Volume of Lesion contoured |
|---|---|

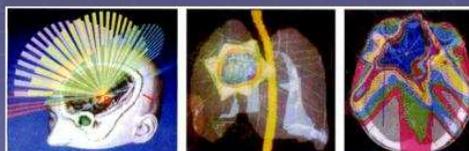
Advancement of High Quality RTx

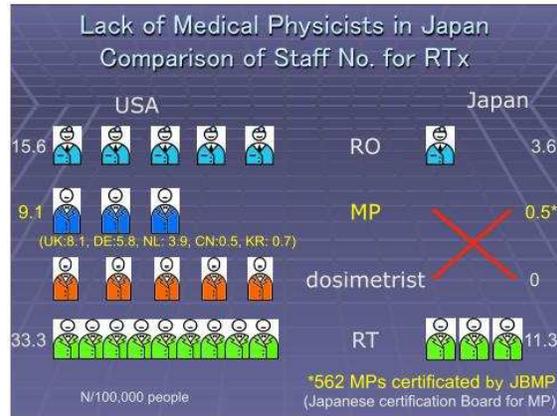
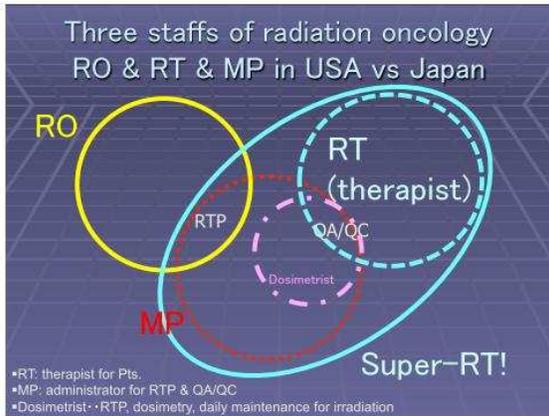
- 3D-Conformal Radiotherapy (3D-CRT)
- IMRT: intensity modulated radiation therapy
- Stereotactic Radiotherapy (SRT)—GK, CK etc
- RTRT (real-time tumor-tracking radiotherapy)
- Particle Therapy



Advanced RT needs MP!

- More computer assisted → black box for radiation oncologists (RO)
- Advanced physics for advanced RTx
- Specialist for physical background of RTx → MP





- ### MPs in Japan are Few.
- MP not a national license, but private
 - Medical work not been established in hospitals.
 - On the other hands, RT(technicians) are very excellent, well trained, so they work in this physical area, so called "super technician".
 - They are, however, too busy to get along with many work in RTx.
 - Then, sharing work should be considered,

Start up '08 Div. of MP in Osaka Univ. Hp.

First set up as national Univ. Hp.

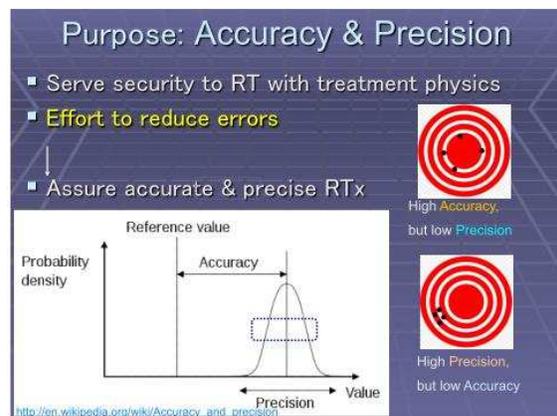
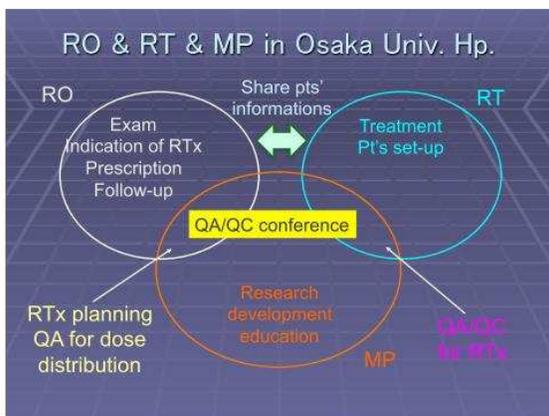
Oncology Center

Dept. RO

Div. MP

1 RO
3 MOs → 2MOs (including 3 Dr.)
1 → 3 Graduate Students

★graduate student

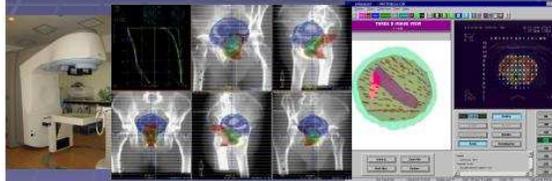


External Beam Radiotherapy

- QA/QC
 - Beam & RTPs
 - Pt's positioning
- IGRT
- Planning
- IMRT
 - MLC-QA/QC
 - Dosimetry

Work 1-1: QA/QC for Beam & RTPs

- Linac: beam (irradiation; hardware)
- Radiation treatment planning system (RTPs; software)
 - Exact dose & precise field?
 - Bring out the planned treatment?
 - Assuring daily stability for treatment.



Beam QA/QC TEST

Calibration water phantom (TG51 standard)

- Calibration MU for all energies of X-ray
- Calculating TPR_{20,10}, R₅₀

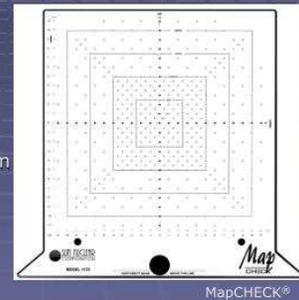
[X-ray]

- Dosimetry at 20cm depth
- TPR_{20,10} & K_Q compare values at com.



Dose QA with 2D Semi-Conductor Array

- MapCHECK[®]
 - 445 detectors
 - > 0.8x0.8mm²
 - 22x22cm
 - Virtual depth: 2cm
 - Temperature-dependence*
 - > 0.54% / °C



*: Med.Phys. 30:870-879,2003.

Research Work

Weekly Verification of Dosimetric Data for Virtual Wedge using a 2-D Diode Detector Array

- A linac manufacturer has recommended that users measure virtual wedge (VW) angle and VW factor as a weekly quality assurance (QA) procedure.
- The purpose of this study was to investigate whether a 2-D diode detector array (MapCHECK[™]) is a useful tool for the verification of dosimetric data for VW.



- 2 dual photon energy linear accelerators (one 4 MV and 10 MV, the other 6 MV and 10 MV)
- Field size: 10 X 10 cm
- Measurement depth: 10 cm
- Treatment planning system XiO ver. 4.33.2 Pinnacle ver. 8.0m
- 2008/9-2009/8 (n=36)

Ogata T et al. Med Dosim. in press

VW angle & VW factor

Energy	VW Angle	XiO	Pinnacle	2D Array Mean (2 SD)	Energy	VW Angle	TPS Data	Measured Mean (2 SD)
4	15	12.9	12.9	13.6 (0.4)	4	15	0.992	0.994 (0.005)
	30	26.2	26.3	27.0 (0.3)		30	0.994	0.992 (0.006)
	45	40.6	40.9	41.2 (0.4)		45	0.993	0.991 (0.009)
	60	56.2	56.7	56.9 (0.3)		60	1.000	0.991 (0.009)
6	15	12.9	13.0	13.6 (0.5)	6	15	0.995	0.991 (0.005)
	30	26.3	26.6	27.6 (0.7)		30	0.989	0.988 (0.005)
	45	40.6	41.4	40.4 (1.0)		45	0.990	0.989 (0.007)
	60	56.1	57.2	56.5 (0.9)		60	0.991	0.990 (0.012)
10 (Linac1)	15	13.4	13.7	14.7 (0.9)	10 (Linac1)	15	0.997	0.994 (0.004)
	30	27.2	27.8	28.5 (0.8)		30	0.992	0.989 (0.004)
	45	41.6	42.8	43.2 (1.0)		45	0.988	0.982 (0.005)
	60	57.1	58.1	57.7 (0.8)		60	0.990	0.985 (0.010)
10 (Linac2)	15	13.4	12.9	13.0 (0.7)	10 (Linac2)	15	0.992	0.995 (0.005)
	30	27.3	27.0	27.1 (0.5)		30	0.990	0.989 (0.005)
	45	41.7	41.5	41.5 (0.7)		45	0.982	0.982 (0.005)
	60	57.2	57.1	57.6 (0.4)		60	0.989	0.984 (0.006)

The maximum 2-fold standard deviation of the measured wedge angle turned out to be within 1.0.
All measured VW factors to be 1.00 ± 0.03.

The 2-D diode detector array was thus found to be useful as a tool for weekly VW QA.

Ogata T et al. Med Dosim. in press

Work 1-2: QA/QC ~ Pt's Positioning

- Pt.(target): posture & positioning
 - How accurate positioning?
 - How manage physiological movement?

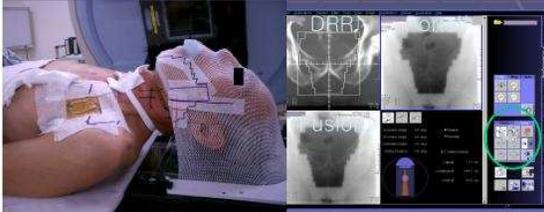


Image-Guided RadioTherapy (IGRT)

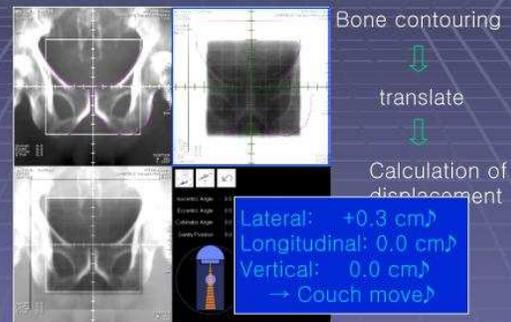
- For accurate pts' position
 - With use of image
 - Correction of position error
 - Image acquired pretreatment (actual position)
 - **Megavoltage (MV) X-ray** with treatment beam
 - Film, CR, EPIDs, Cone beam CT → Osaka Univ. Hp.
 - Kilovoltage (kV) X-ray with on board imager
 - Fluoroscopy, Cone beam CT
 - Stereotactic infra-red light (CCD camera)

Image Guide with EPI (OUH)



Ref.: S. Korreman, et al. The European Society of Therapeutic Radiology and Oncology-European Institute of Radiotherapy (ESTRO-EIR) report on 3D CT-based in-room image guidance systems: a practical and technical review and guide. *Radiother Oncol.* 94(2):129-44. 2010.

2D-2D Registration / Contour of Bone

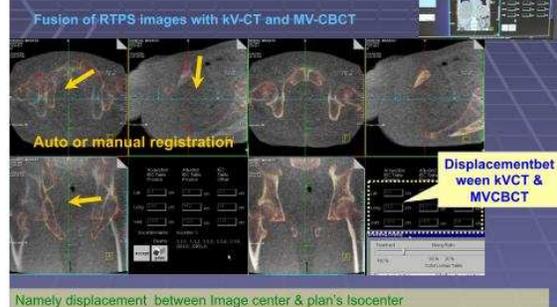


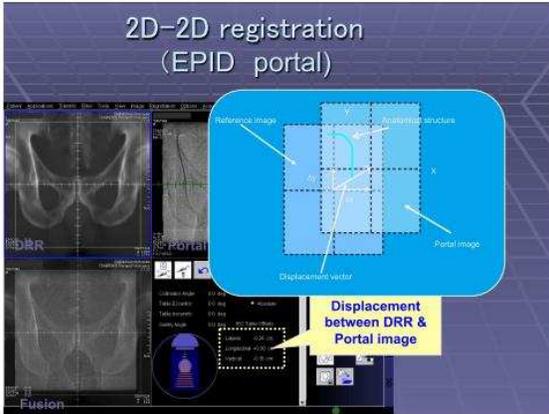
Mega Voltage X-ray Cone-Beam CT (MV-CBCT) installed in Linac

- Treatment Beam (4 or 6MV) to EPID
- 200 images during 200° rotation
- 3D image by reconstruction



3D-3D Registration with Correction by MVCBCT





Work 2: Radiation Treatment Planning

- CT image to PC, OAR&old field set up
 - RO: → CTV&prescribes
- Set Tx beam
- Confirm with RO → OK
- Submit the final plan
 - RT: input → Tx system
- Check input contents
 - = Double check with RT

IMRT (Intensity Modulated Radiotherapy)

- Piles up the optimized dose distributions

Only computer-assisted!

IMRT QA 1. MLC Position

Non-gap test

Fence test

- Non-gap test or Fence test reveals MLC positioning accuracy.
- If position error over allowed value is detected, calibration of leaf position has to be performed.

IMRT QA 2. Dose Distribution for Each Case

Combined All Beams Each Beam

Absolute dose Dose distribution Absolute dose

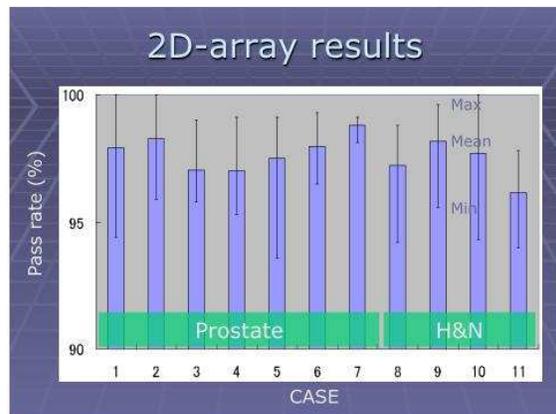
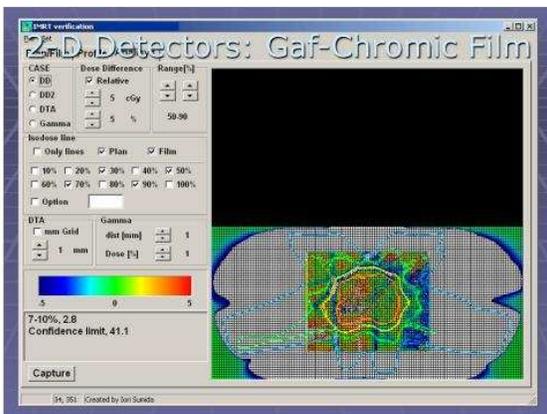
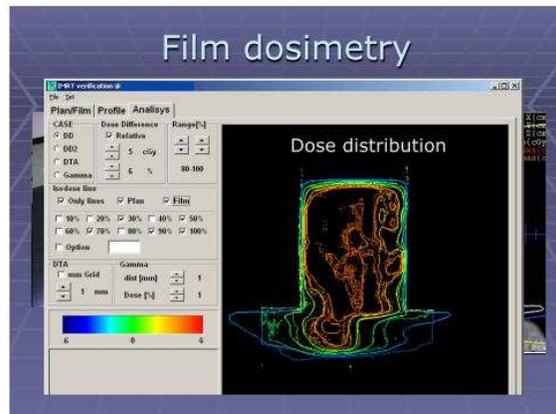
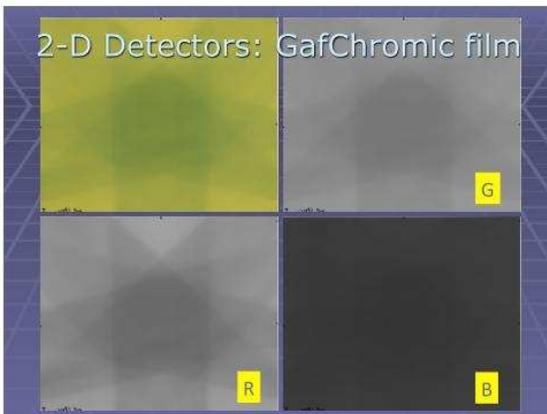
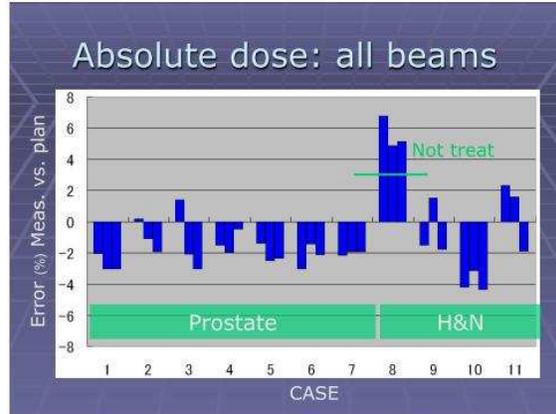
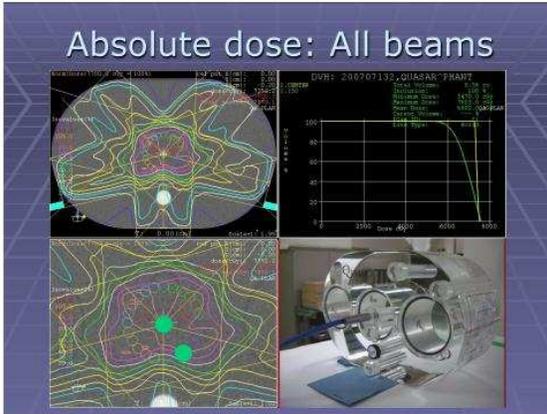
Film

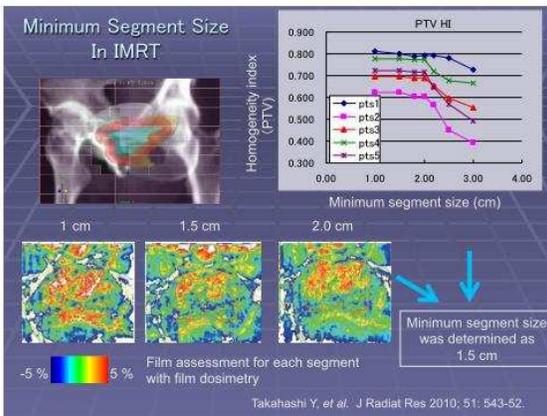
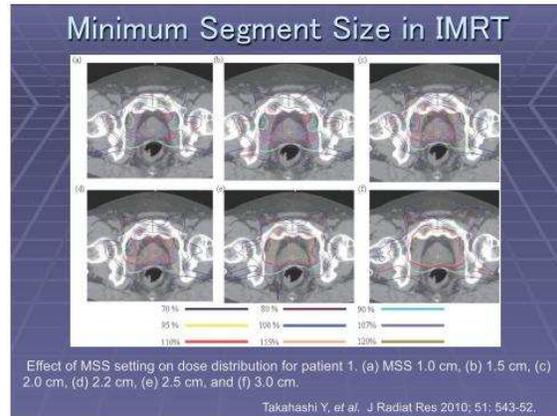
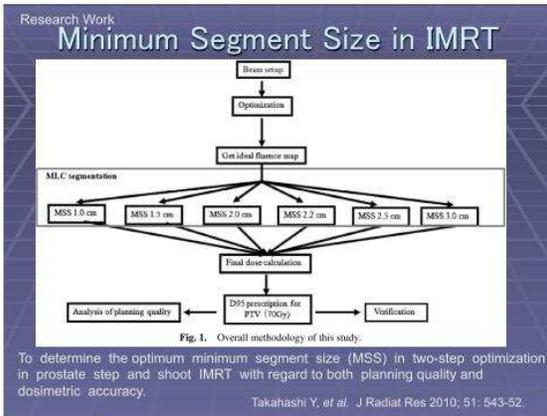
IMRT's Dose QA

1D 2D 3D

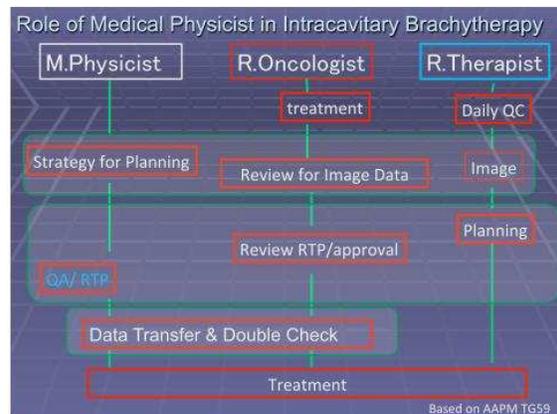
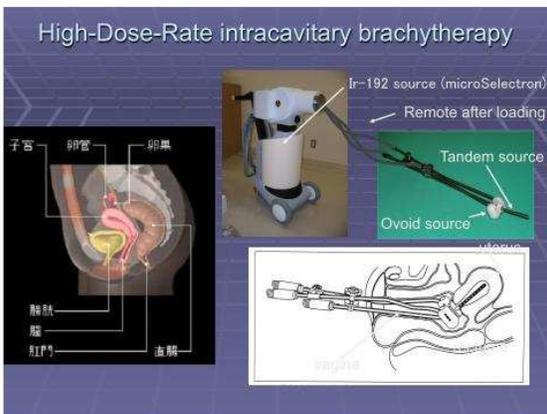
RTPS

Point dose





- ### Brachytherapy
- Modality
 - Staff
 - Planning
 - QA/QC



Staff Role for Interstitial Brachytherapy (ISBT)

ISBT for prostate cancer or cervical cancer
Metal needle applicator inserted by RO
MP plans optimized source position on
CT-based target volume.

Development of Independent Verification of Treatment Planning

Predicting total dwell time

$$D(r, \theta) = S_A \times \Lambda \times \frac{G_L(r, \theta)}{G_L(r_0, \theta_0)} \times g_L(r) \times F(r, \theta) \times Dwelltime$$

activity Total dwelltime

$$Dwelltime_t = \frac{D(r, \theta)_{prescription_t} \times Sk_m \times Dwelltime_m}{D(r, \theta)_{prescription_m} \times Sk_t}$$

m: Model
t: every treatment

Comparing Dose Shape of Every Treatment with that of Benchmark Plan

ICRU report 38 recommends recording dh, dt, and dw on every treatment

Do dh, dt, dw always show almost similar?

Independent Verification using in-house Software

Parameter	Planned	Plan	Difference
dh (cm)	83.2	84.2	1.0 mm
dt (cm)	48.1	48.9	-0.8 mm
dw (cm)	52.8	53.5	-0.7 mm
Dwell time 1 (s)	786	818.5	-32.5 %
Dwell time 2 (s)	775.4	818	5.0 %

Daily QC

1. Area Monitor
2. In safe lamp lightening
3. Area Monitor lightening
4. On X-ray image lamp lightening
5. System self test
6. Unlock drum
7. Stationary position of source (5)
8. Area monitor acting
9. Stationary time of source (~plan)
10. Print out acting
11. Assess interrupt function

Research Work

Single Seed Assay

- Based on AAPM TG-56 tolerance
 - Med. Phys. 24;1557-98;1997

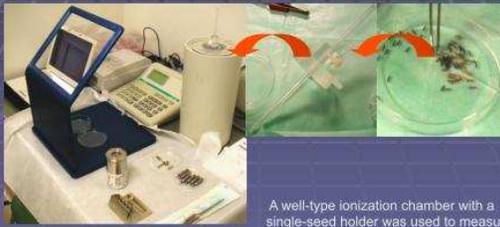
Code of practice for brachytherapy physics: Report of the AAPM Radiation Therapy Committee Task Group No. 56

Recommendations of the American Association of Physicists in Medicine (AAPM) for the practice of brachytherapy physics are presented. These guidelines were prepared by a task group of the AAPM Radiation Therapy Committee and have been reviewed and approved by the AAPM Science Council. © 1997 American Institute of Physics [S0094-2405(97)01410-7]

- We investigated the difference between measured and manufacturer's stated source strengths in a single model ¹²⁵I seed.

Verification of air-kerma strength ¹²⁵I seed for permanent prostate implants in Japan
Sumida I, et al. Int J Clin Oncol 14:525-528,2009.

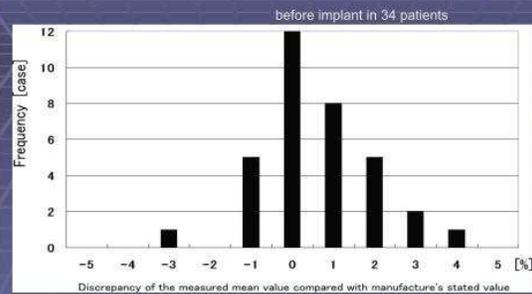
Measurement Procedure - Every Treatment -



A well-type ionization chamber with a single-seed holder was used to measure the source strength of 2412 ¹²⁵I seeds

Sumida I, et al. Int J Clin Oncol 14:525-528,2009.

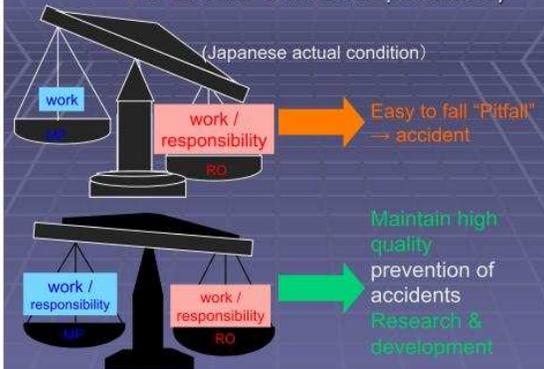
Comparison between meas. vs. nominal strength



This is the first report of a single-seed assay performed for the model STM125I seed. The manufacturer's stated strength agreed well with the measured value.

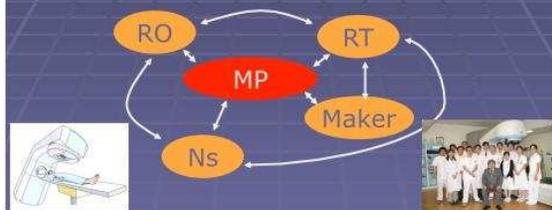
Sumida I, et al. Int J Clin Oncol 14:525-528,2009.

MP should Share Responsibility



MP's Roll in RO Team

- MP plays a central roll in CART
- Advice & Support Education to RO & RT
- Developing new Tx methods and systems



Summary

- RT advance, more accurate & precise planning and QA/QC required
- More dependent to computer-assisted
- Medical physicists are necessary for improving physical bases in Dept. of RO
- OUH established Div. MP & their works
- Accurate beam & pt. set-up and Precise dose distribution can be given by our MPs.
- Clinical research works were published.

Thank you for your attention

Recommending me to today's lec.

Prof. Indra J Das

Prof. Teruki Teshima

Materials from co-workers

Ph.D. Iori Sumida

Ph.D. Yutaka Takahashi

Ph.Dr. Toshiyuki Ogata

M.S. Yuichi Akino

M.S. Masashi Yagi

