IMAGE BASED / GUIDED BRACHYTHERAPY

IN

CERVICAL CANCERS

On behalf of Department of Radiation Oncology

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IMAGE BASED / GUIDED BRACHYTHERAPY IN CERVICAL CANCERS

- **Pre- Requisites**

  - Knowledge of cervical cancer biology & patterns of spread

  - Basic knowledge of RT (XRT + ICBT) details

  - Basics of ICBT procedure and planning

- **Learning Objectives:**

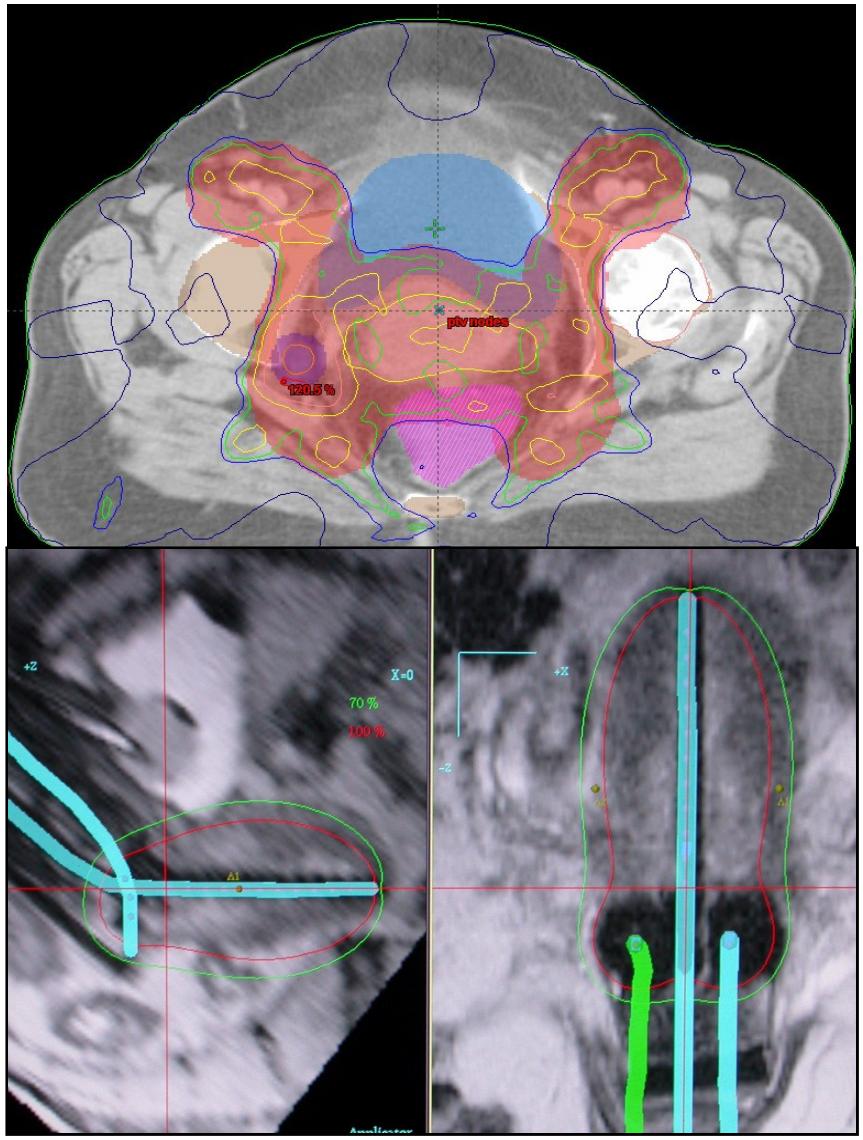
  - Concepts of Image Guided / Based ICBT

  - Various steps for Image Based Brachytherapy

  - Proof of the Principle: Clinical Outcome & Evidence

BACKGROUND

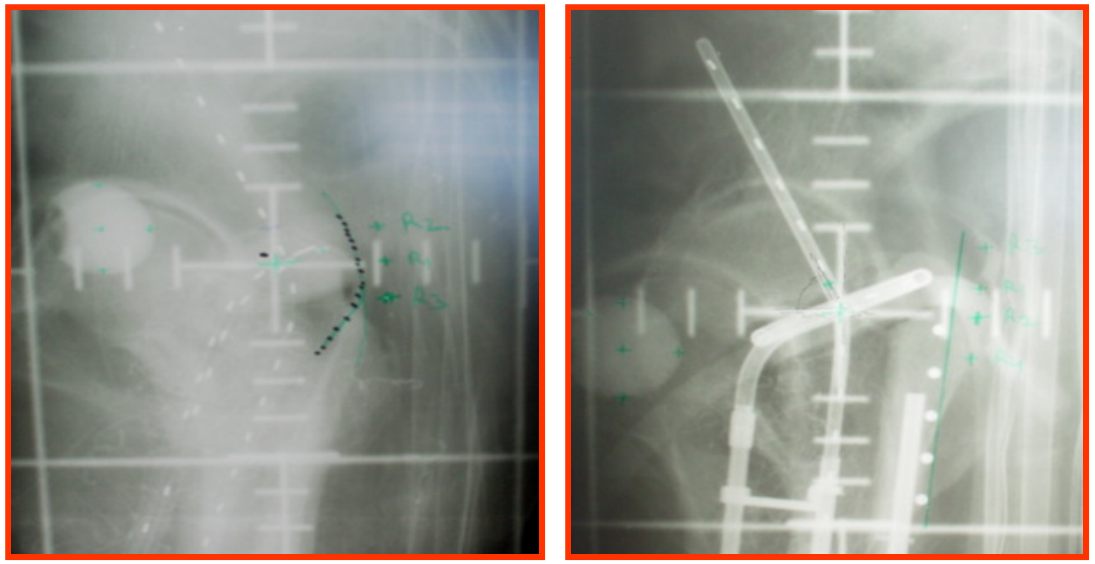
- Technological advances in external radiation : Continues to be a success!
- Similar advances in Brachytherapy: but at Snails' pace
- Brachytherapy: Oldest form of IMRT



BACKGROUND

Drawbacks of 2D Planning

- Limitations of Point A Based Dosimetry
- Target Volume Assessment
- Delineation of Organs at Risk
  - Rectum
  - Bladder
  - Sigmoid
  - Small intestine
  - Vaginal mucosa

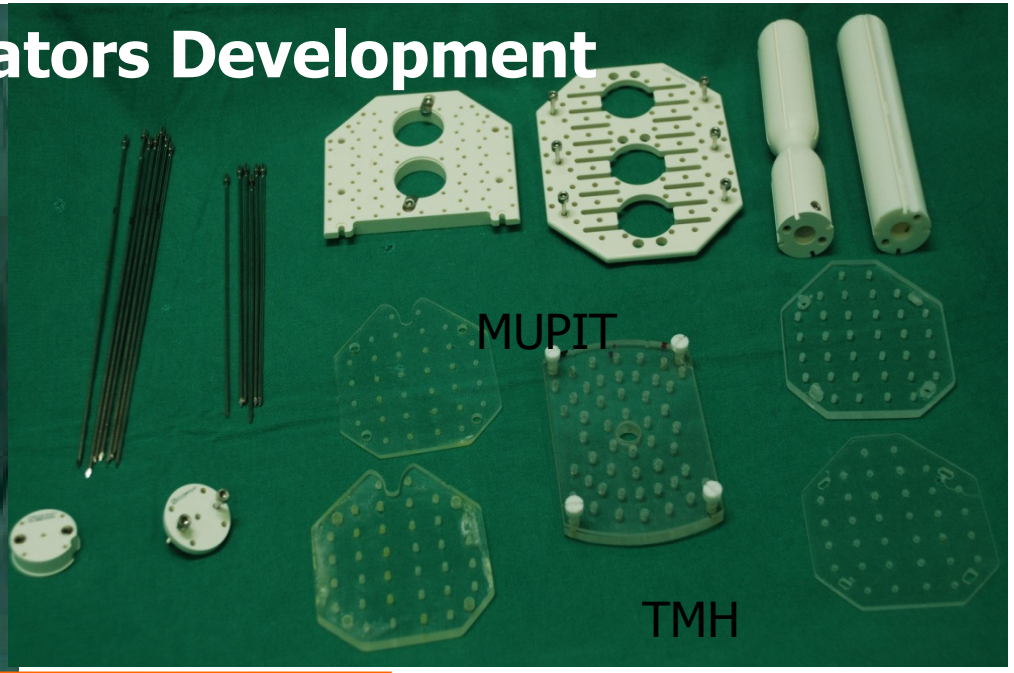


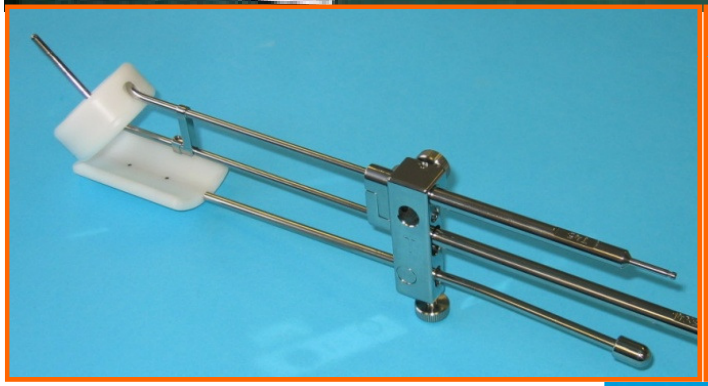
- Brachytherapy: Conformal with Image Based

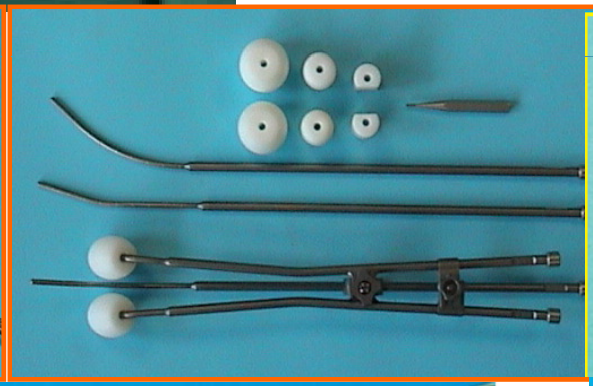
ADVANCES IN GYNAECOLOGICAL BRACHYTHERAPY

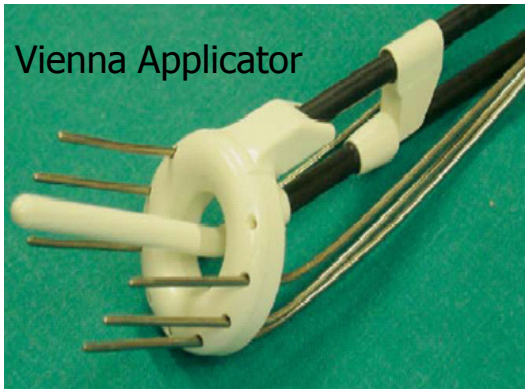
- Applicator development: *Intracavitary (IC), Interstitial (IS) & IC+IS*
- In corporation of Newer Imaging Modalities: *CT, MR, PET, etc.*
- Advances in Treatment Planning Systems
- Image / Volume Based Brachytherapy

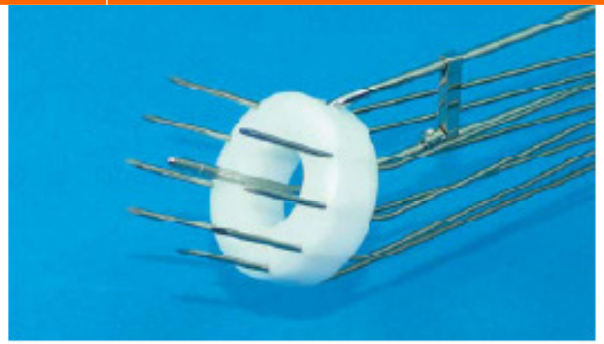
Applicators Development



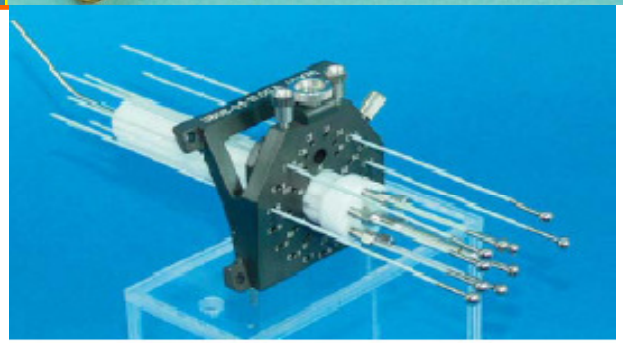








CT Vienna System with Titanium Needles

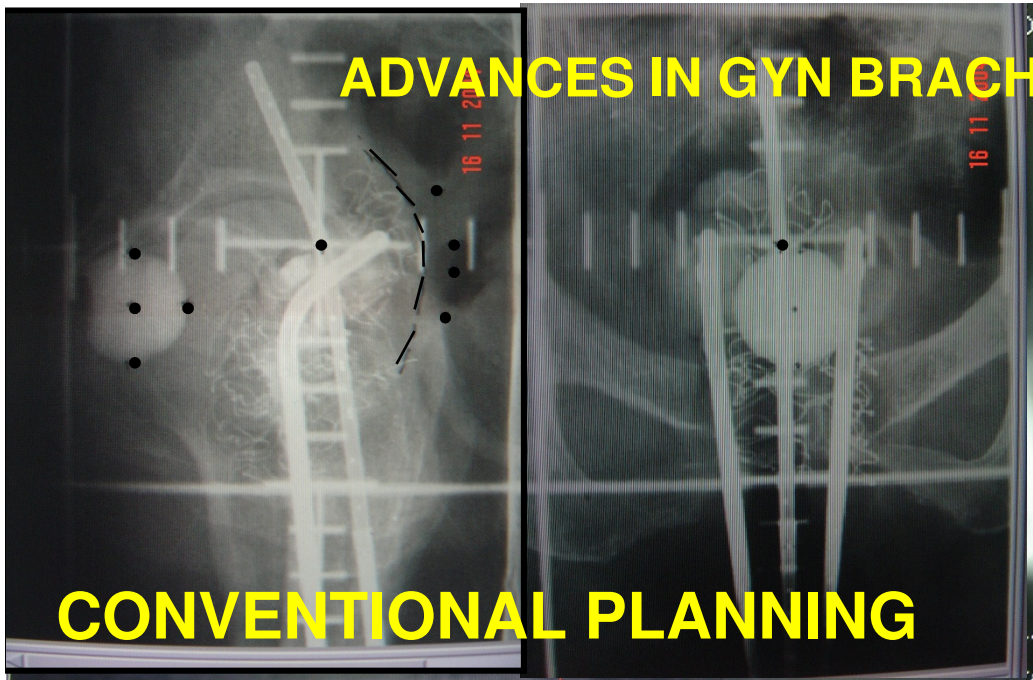


CT MAC. Interstitial GYN Template

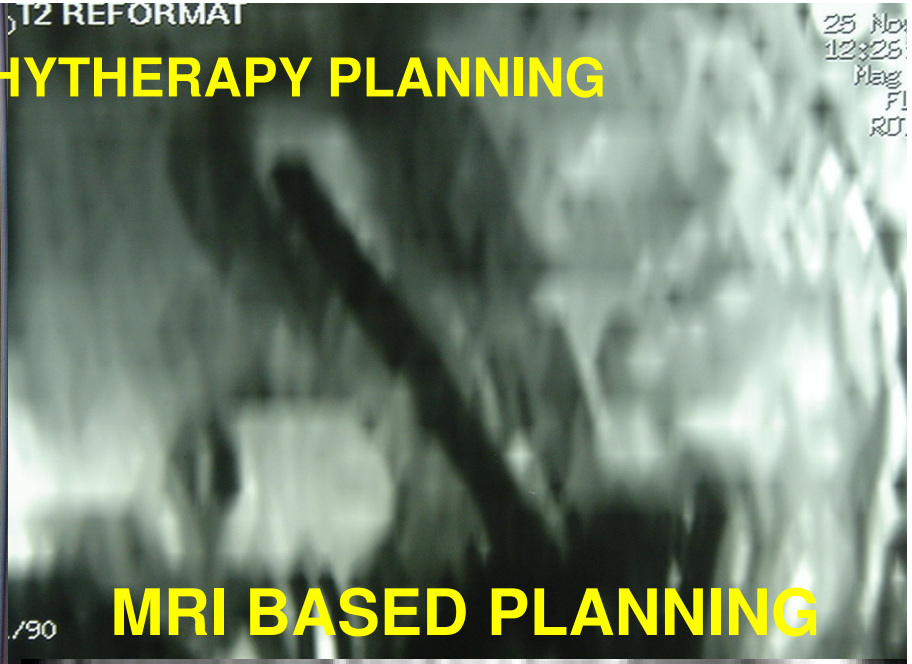
In corporation of Newer Imaging Modalities

- 2D Planning : Orthogonal X-ray Based (STD)
- 3D Planning :
    - US: TMH Experience (Reverse ICRETT)
    - CT Scan: Interstitial Brachytherapy
    - MRI: TMH Experience
    - PET etc.

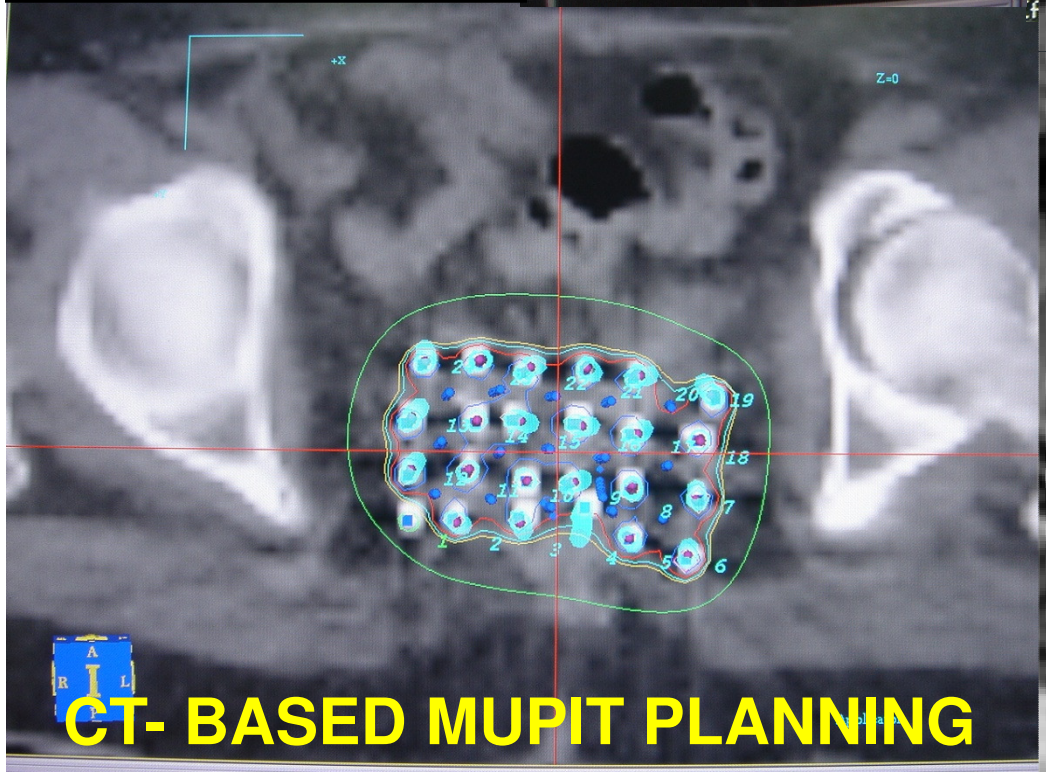
ADVANCES IN GYN BRACHYTHERAPY PLANNING



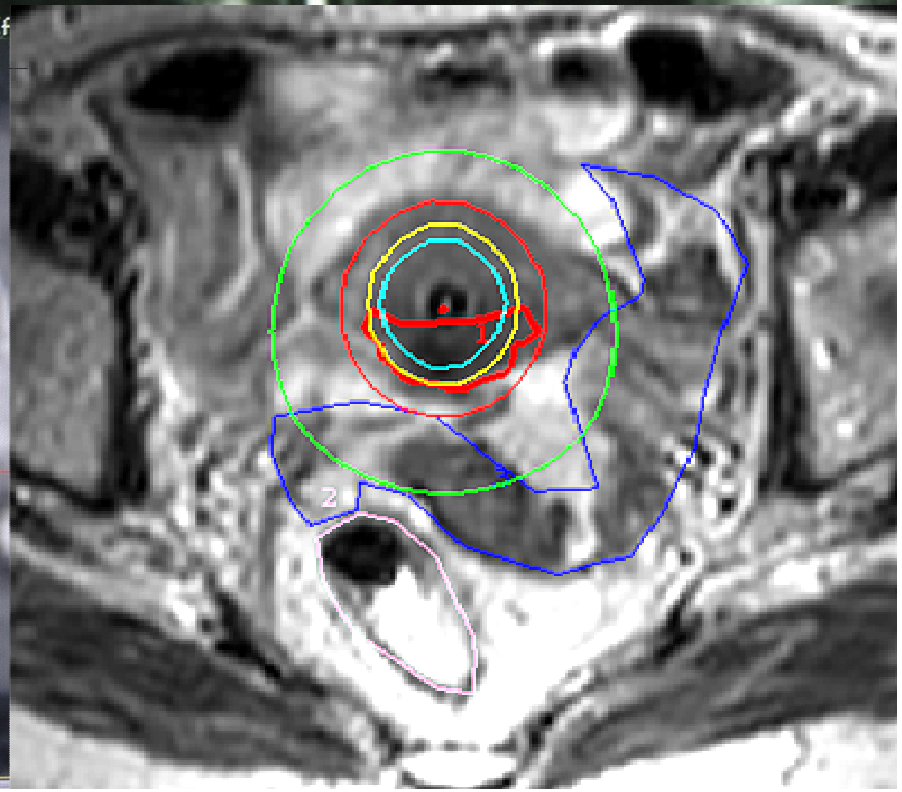
CONVENTIONAL PLANNING



MRI BASED PLANNING

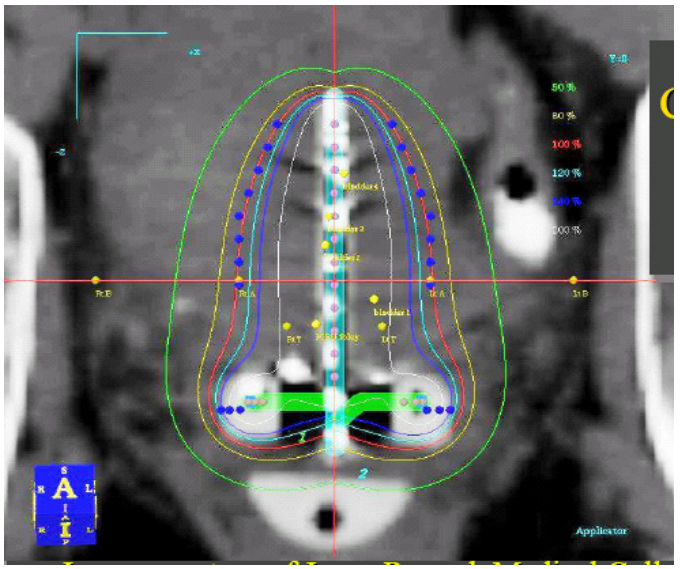


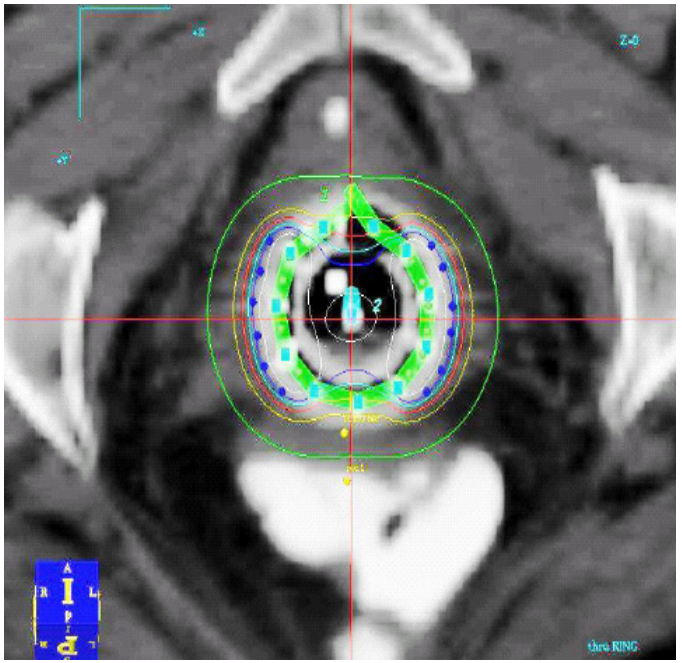
CT- BASED MUPIT PLANNING



CT Scan Based Planning

- Wide acceptability due to its use in external radiation therapy
- Bladder and Rectum visualization better
- Applicator Reconstruction : Easy
- Limitations:
  - Metal artifacts → special applicator
  - Poor differentiation b/w uterus, para-uterine tissue, cervix and tumor

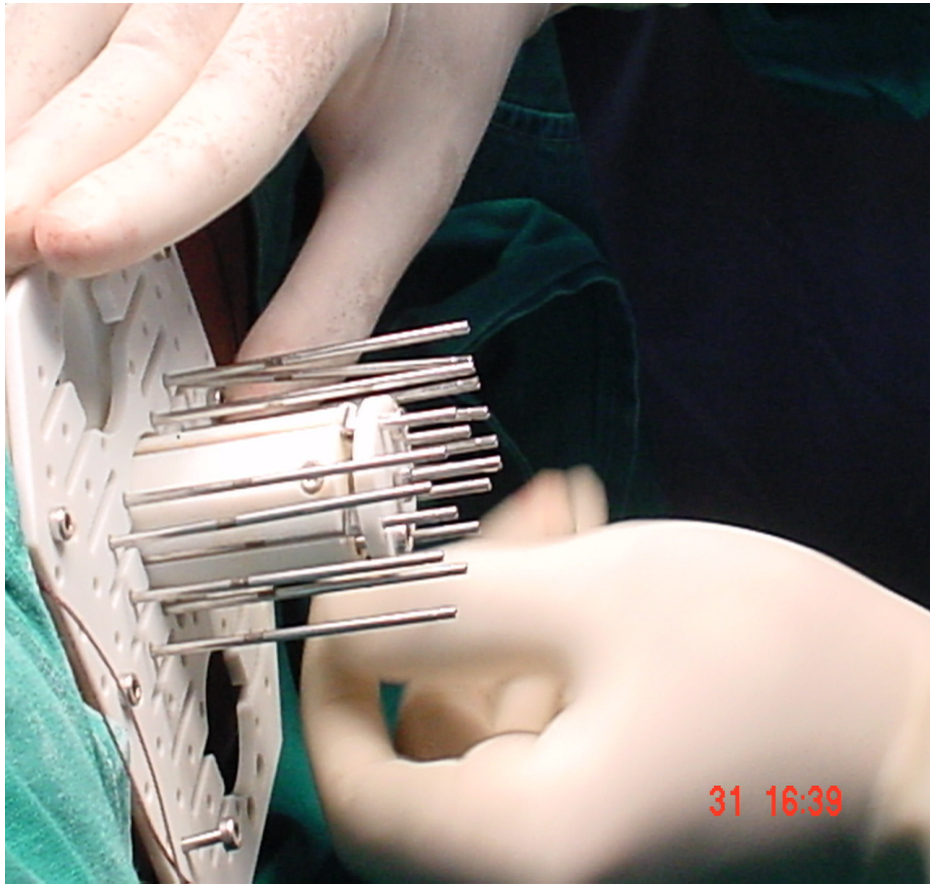




INTERSTITIAL BRACHYTHERAPY IN CERVIX

INDICATIONS:

- Extensive Parametrial Disease
- Narrow/distorted vagina
- Post-hystercetomy Recc.
- Distal Vaginal involvement
- Persistent disease after radical RT

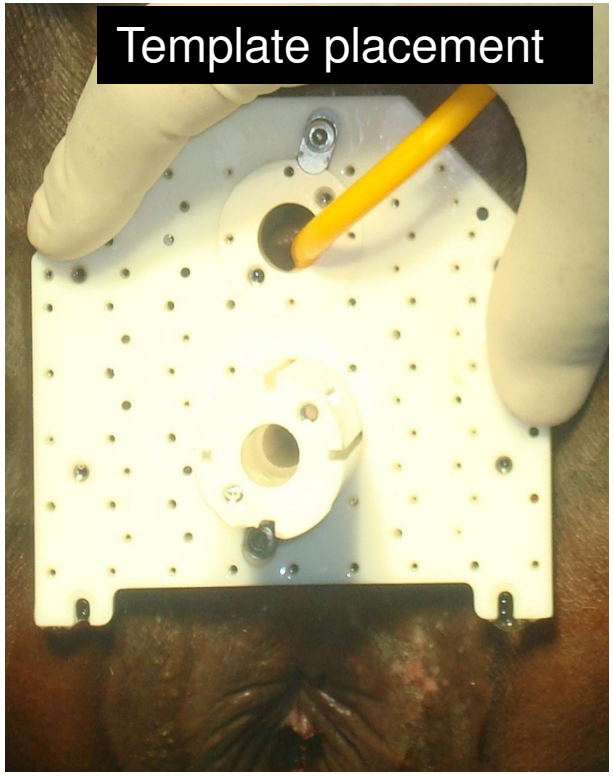


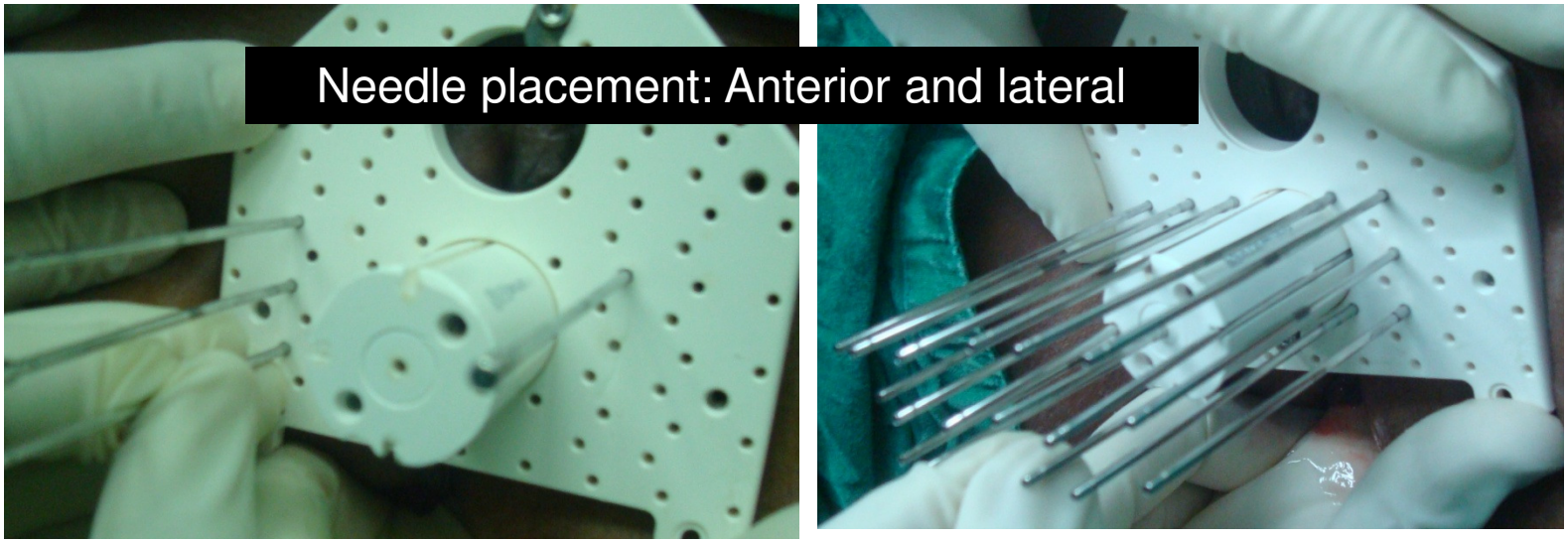
APPLICATORS:

- Syed-Neblett Template (LDR)
- Martinez Universal Perineal Interstitial Template (MUPIT-HDR)
- ***Complication rates requiring surgical intervention are high***

IJROBP 1985, GYNAE ONCOL 1995;

Technique





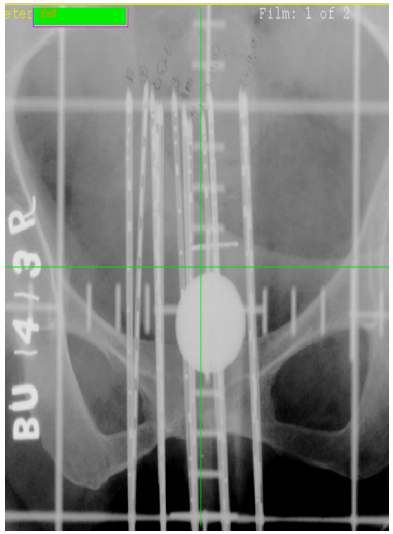
Under per-rectal guidance / TRUS / MR based

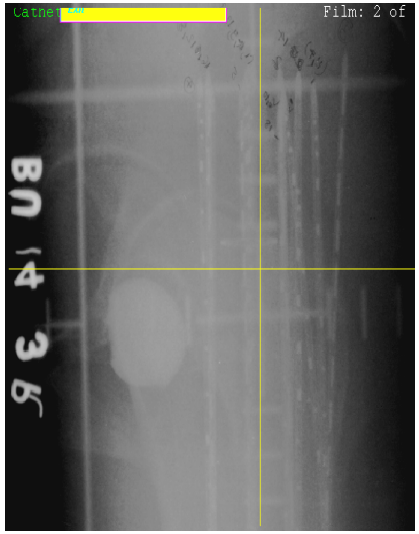
Perineal Interstitial HDR Brachytherapy

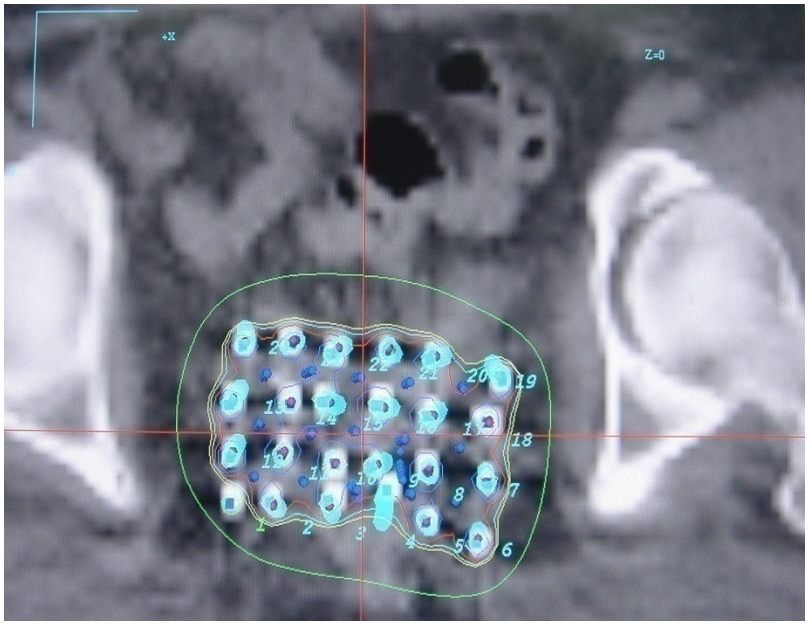
Martinez Universal Perineal Interstitial Template

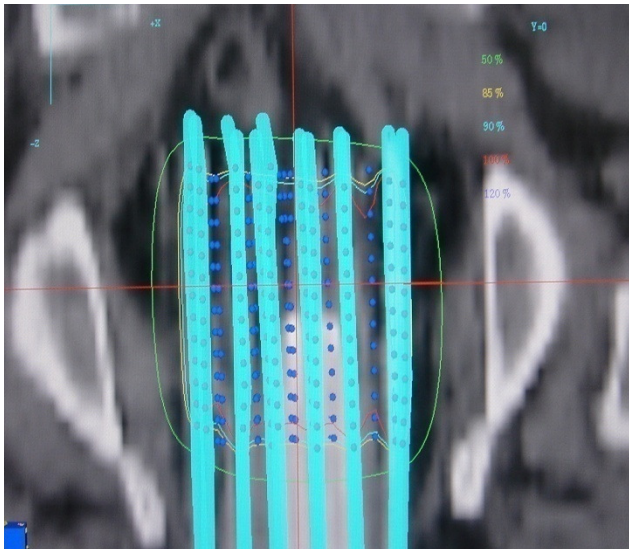
- EUA : Residual disease, pelvic anatomy etc. assessed
- 18 G stainless needles: , Multiple plane implant
- CT Scan images with 3-5 mm slice thickness
- Image acquisition and Delineation
- Treatment planning:
    - Catheter reconstruction and Source loading (6-6.5 cm)
    - Basal dose points (Paris Dosimetry system)
    - Dose prescription : 3.4 – 4 Gy per fraction @ 2# per day 6 hrs apart x 4-5 #
    - Optimization : Geometric +/- graphical
    - Plan evaluation (DVH) : Target and OAR's

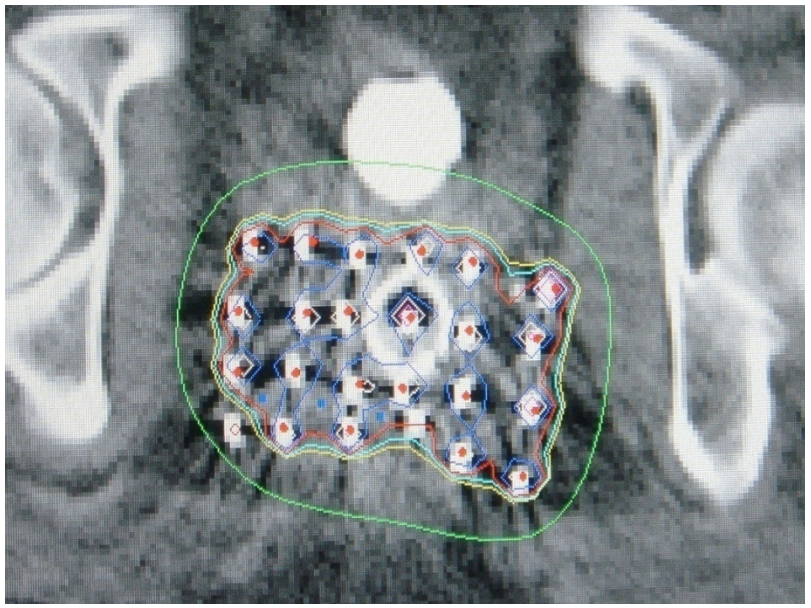
Implant Orientation and Needle identification is very important











- Dosimetry
- Dose : 3.4 – 4 Gy /fraction
- 2 fractions per day 6 hours apart
- No of fractions : 4-6 depending on the response

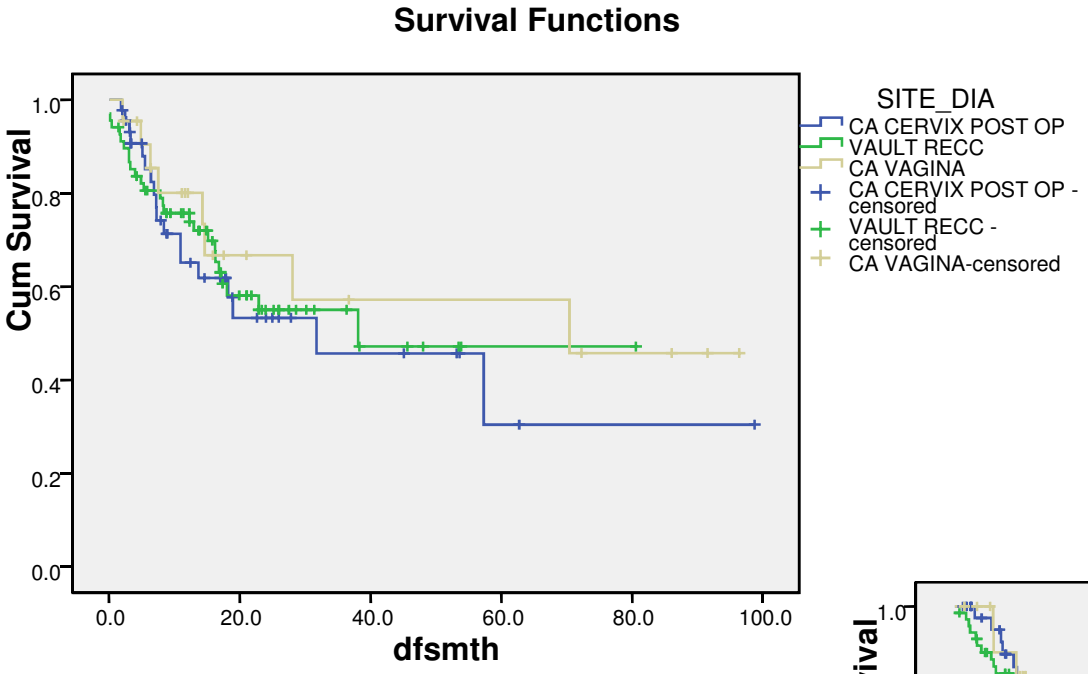
MUPIT - HDR : TMH Experience

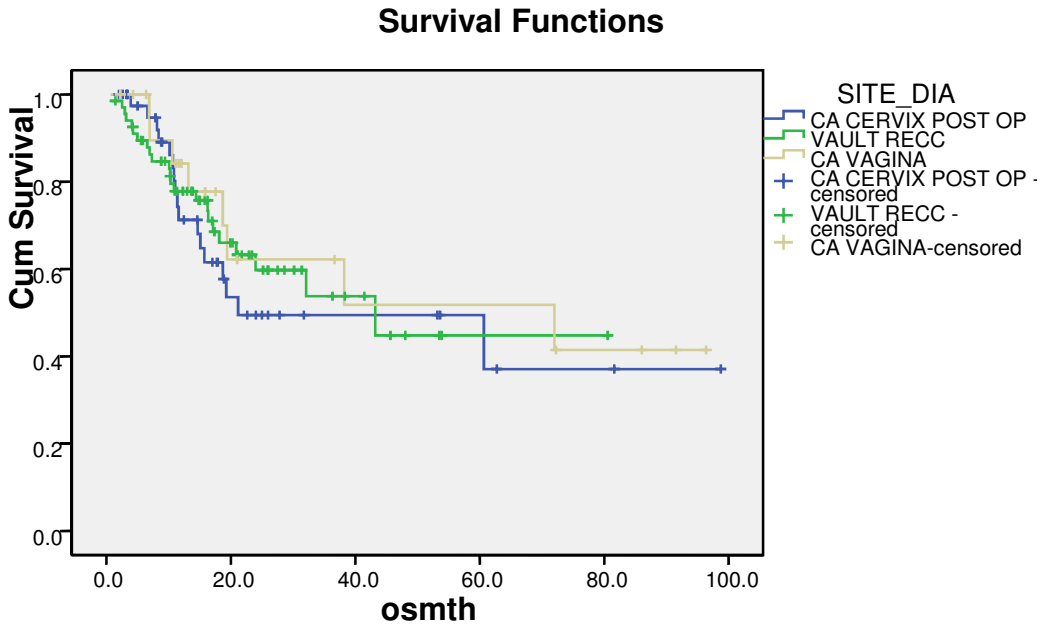
N = 135 pts (1995 – 2008)

MEAN FU : 30 MONTHS (MEDIAN 28 mths)

	Post Inadvertant Sx CA cervix **(N=45)**	**CA VAULT (N=68)**	**CA VAGINA (N=22)**
CONTROLLED	**27 (60%)**	**42 (61.8%)**	**14 (63.6 %)**
PERSISTANT DIS	**4 (8.9%)**	**5 (7.4%)**	**1 (4.5 %)**
CENTRAL RECC	**9 (20 %)**	**16 (23.5%)**	**3 (13.6 %)**
LOCO-REGIONAL	**2 (4.4 %)**	**1 (1.5%)**	**2 (9.1 %)**
L-R + DISTANT	**1 (2.2 %)**	**3 (4.4 %)**	**2 (9.1 %)**
DISTANT	**2 (4.4 %)**	**1 (1.5 %)**	**0 (0 %)**

DFS & OAS



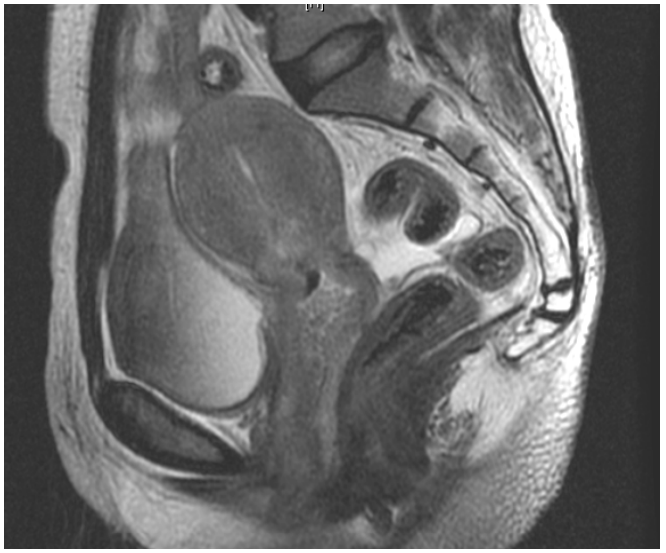


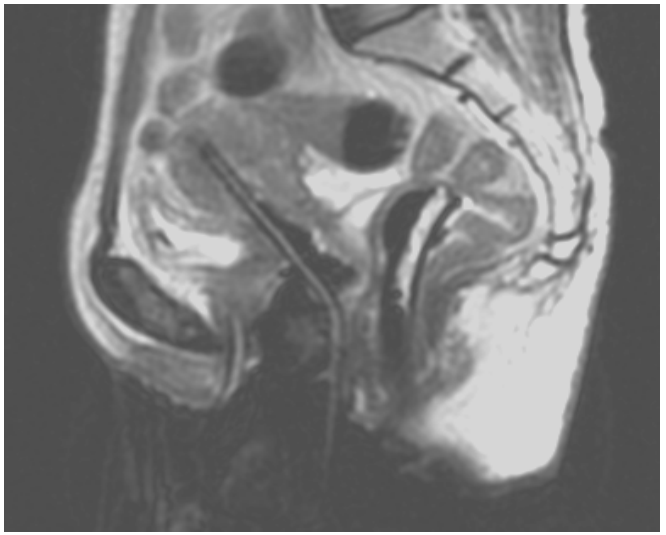
Late toxicity

- **4 pts: Grade III RT Proctitis**
- **2 pts Grade IV rectal (RVF: had disease)**
- **Poor documentation of late seqeulae**

MRI Based Brachytherapy Planning

- Good soft tissue contrast
- True multi-planar imaging
- Differentiation between cervix, uterus, tumor and para-uterine tissue
- Rectum, bladder, sigmoid and small intestine visualized
- Limitations:
  - Expensive
  - Special applicator
  - logistics



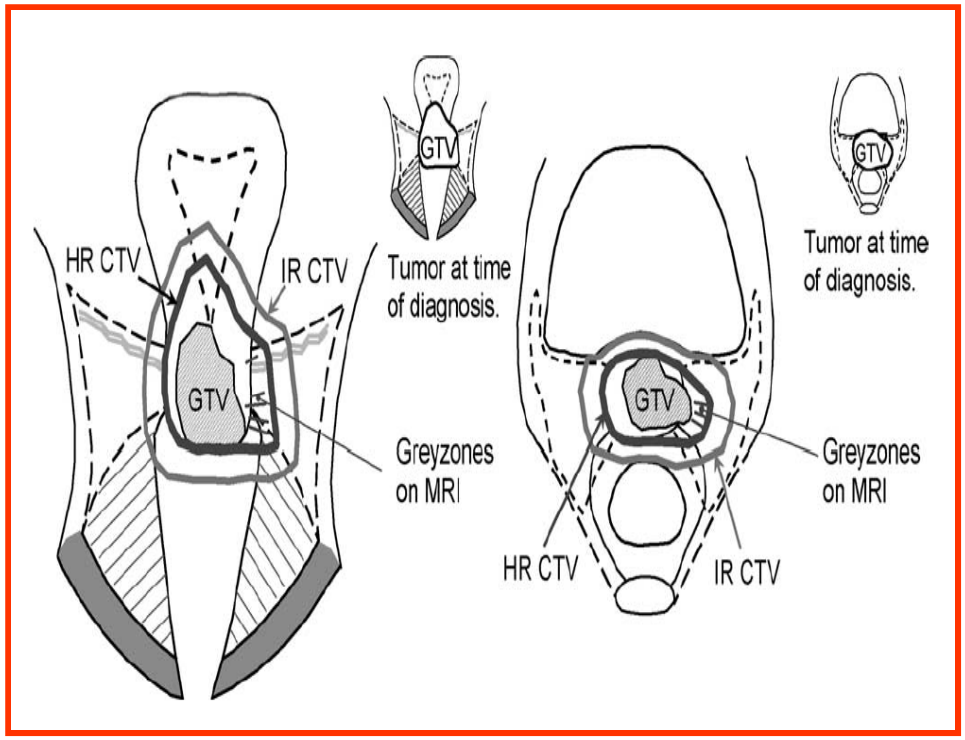


MR Based ICA in use last 6 - 9 years now

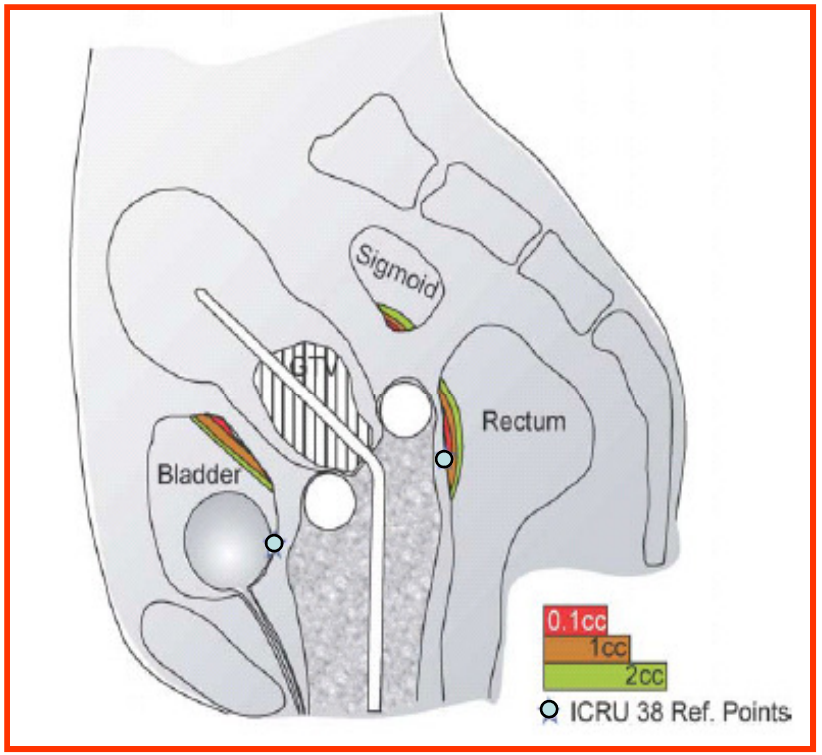
Understanding of MR Pelvic anatomy : Vital

GEC - ESTRO RECOMMENDATIONS

Dose Volume Parameters for Targets & OAR's



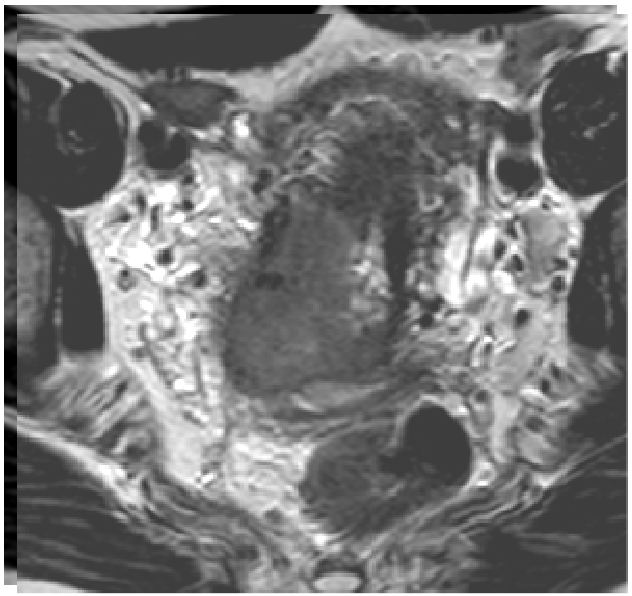
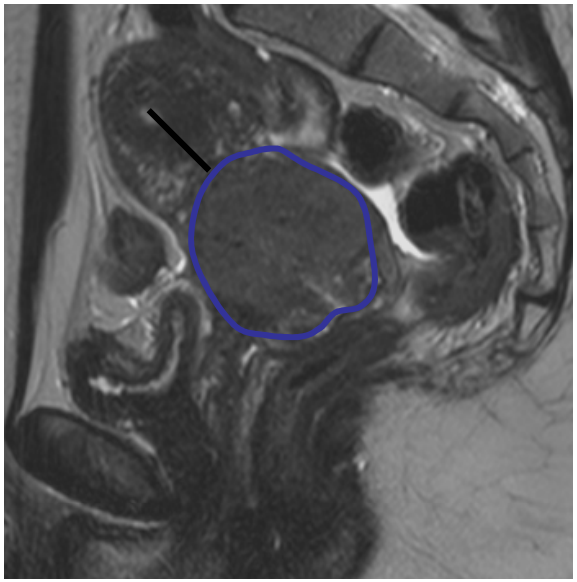
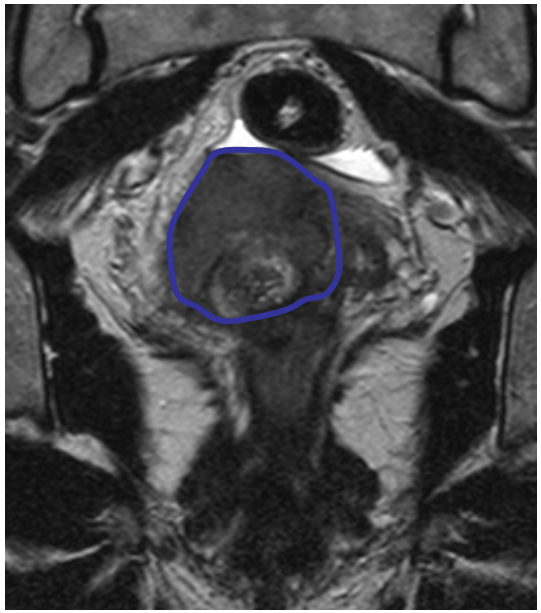
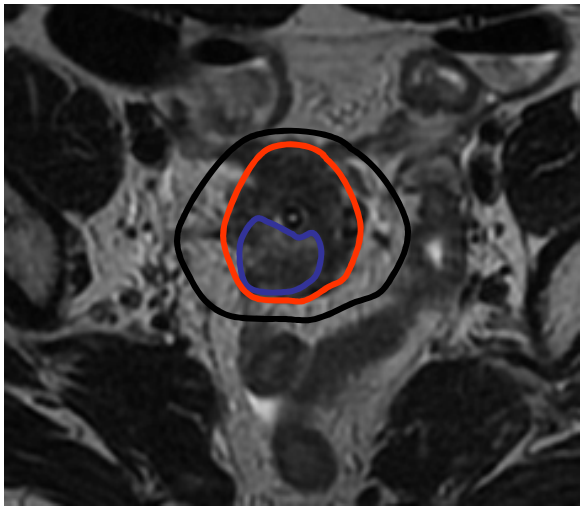
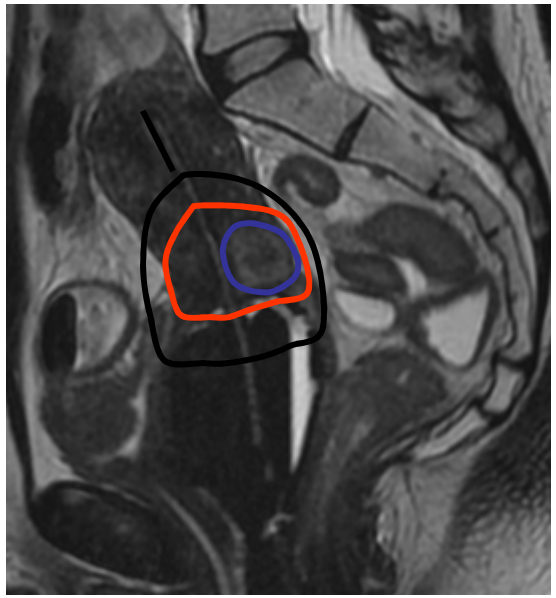
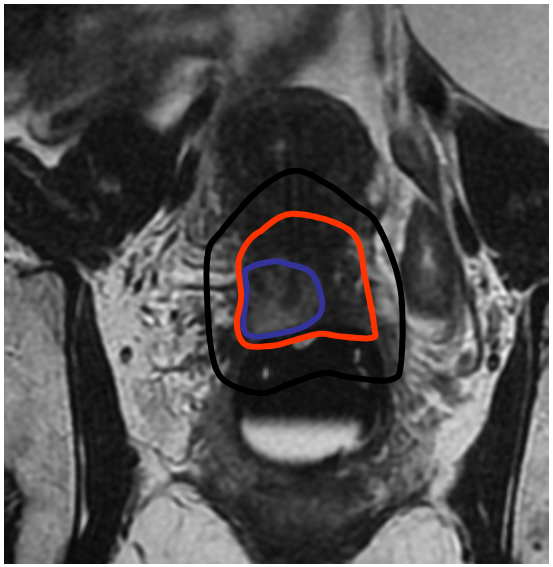
D100, D90 for GTV, HR CTV, IR CTV



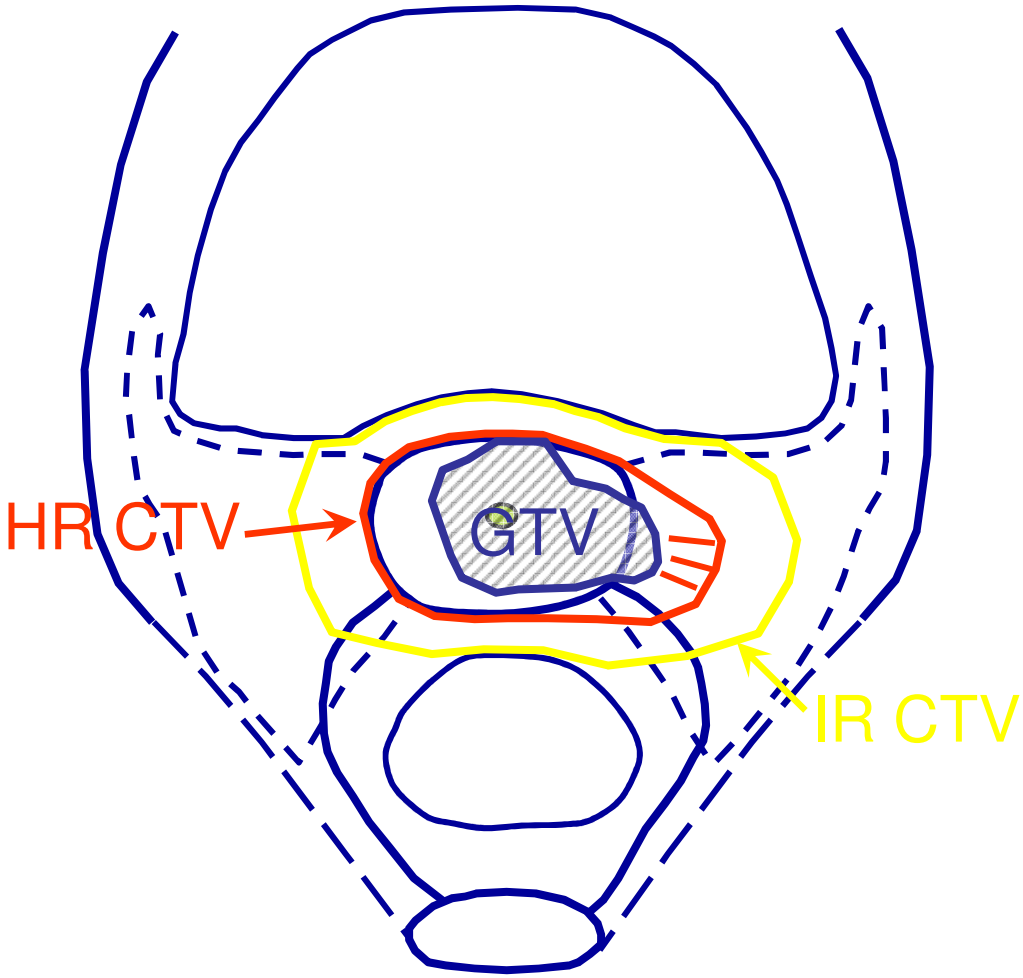
D0.1cc, D1cc, D2cc for OARs

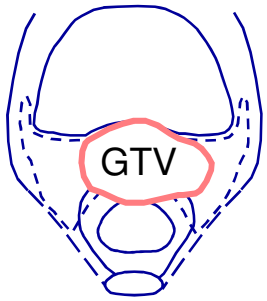
Radiother and Oncol 2006; IJROBP 2007

Example : Stage IB2

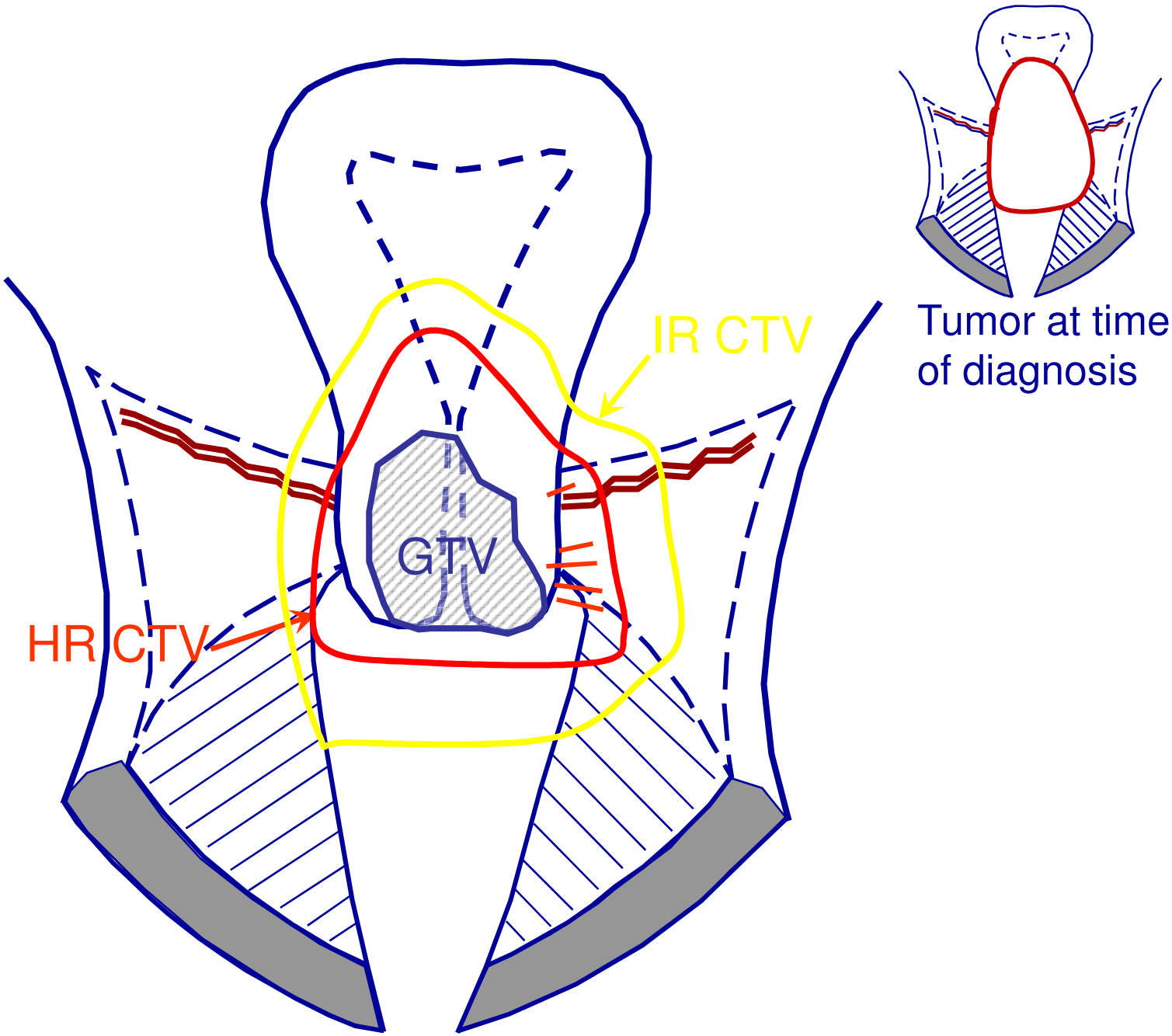







GEC-ESTRO recommendations



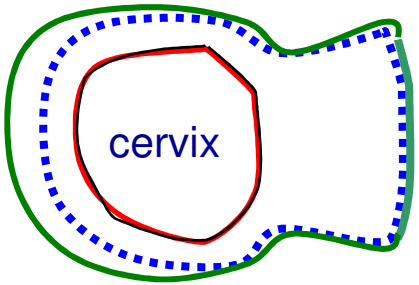


Tumor at time of diagnosis.

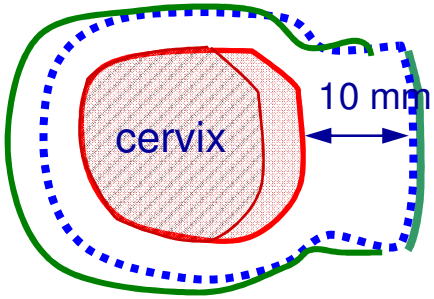

IR CTV
GTV
HR CTV
Tumor at time
of diagnosis

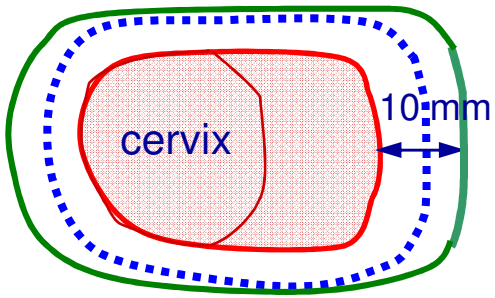
CTV BT

Complete remission

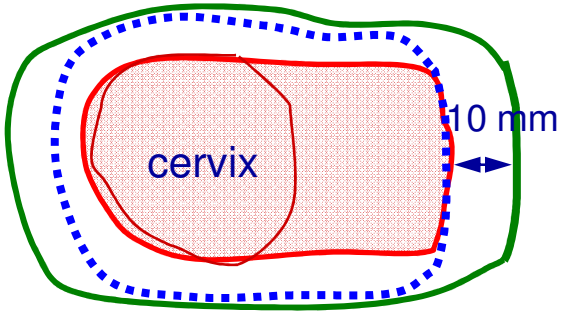


Partial remission





Stable disease



Legend

HR-CTV

IR-CTV

Initial tumour extension
(at diagnosis)

Residual disease

MR IBB in Cx Cancers : TMH Protocol

- **GYN Joint Clinic Staging**
- **Planned for Radical RT+/- CT (weekly Cisplatin 40 mg/m2 x 4-5#)**
- **External + MR Based Brachytherapy (4^{th} – 5^{th} week onwards)**
- **Applicators : MR Compatible Tandem Ovoids / Ring / Interstitial**
- **MR Protocol :**

  - 1.5 T with body coil

  - FSE T1 as localizer + FSE T2 (axial, saggital and coronal)

    with 3 - 4 mm slice thickness and 0 - 1 mm slice gap

- **Target Volumes : GTV, HR - CTV, IR - CTV**
- **OAR's : Rectum, Bladder and Sigmoid (0.1, 1, 2 cc)**
- **Doses : EQD2 values**

GEC ESTRO RECOMMENDATIONS

- **GTV:**

  macroscopic tumour extension at time of brachytherapy…

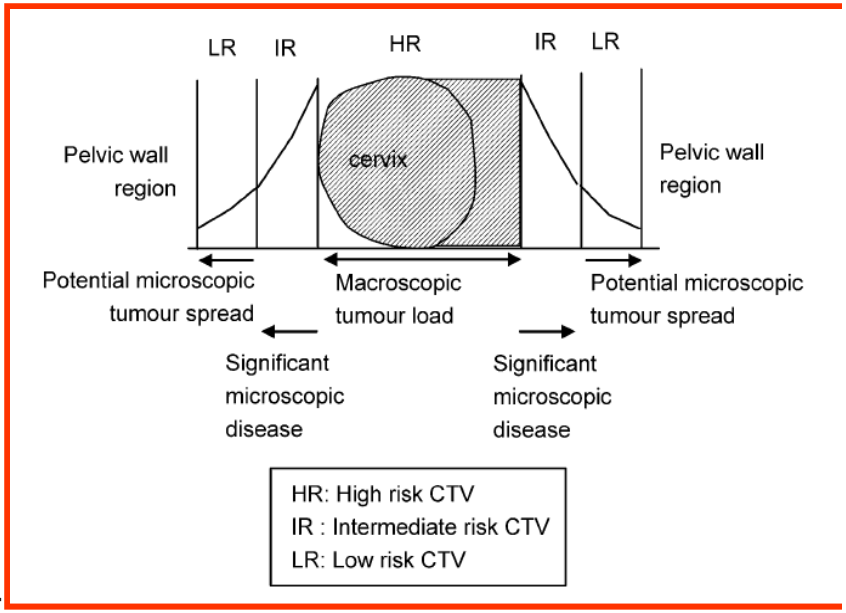
  High signal intensity mass(es) (FSE, T2) in cervix/corpus, parametria, vagina, bladder and rectum

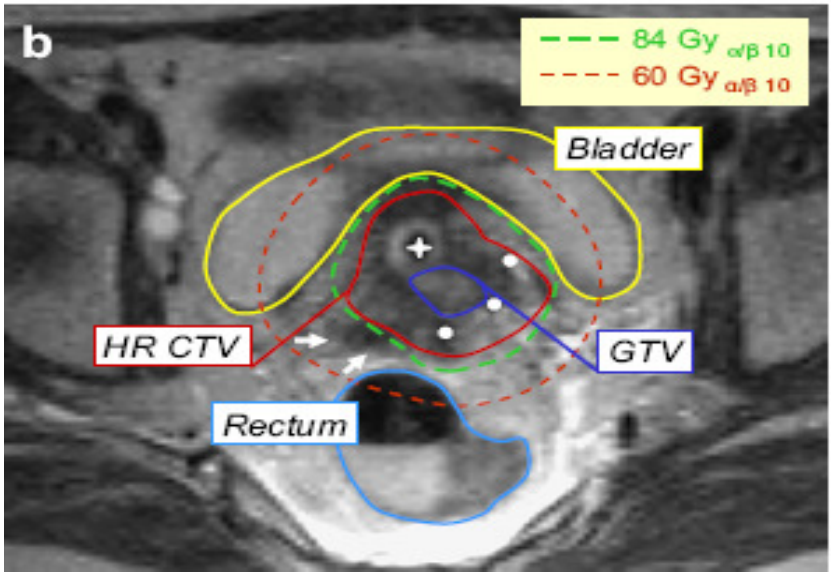
- **HR-CTV:**

  includes **gtv, whole cervix**, and **presumed extracervical tumour extension**. Pathologic residual tissue(s) as defined by palpable indurations and/or **grey zones** in parametria, uterine corpus, vagina or rectum and bladder are included in HR-CTV. No safety margin are added.

- **IR-CTV:**

  encompasses the **HR-CTV** different **safety margins** are added according to the treatment strategy, tumour size and tumour regression. **In any case a minimal safety margin of 5 to 15 mm** have to be added.

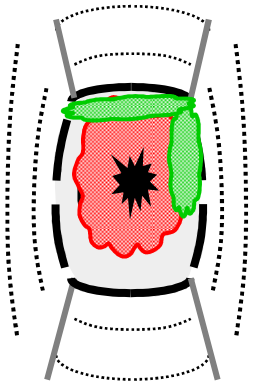


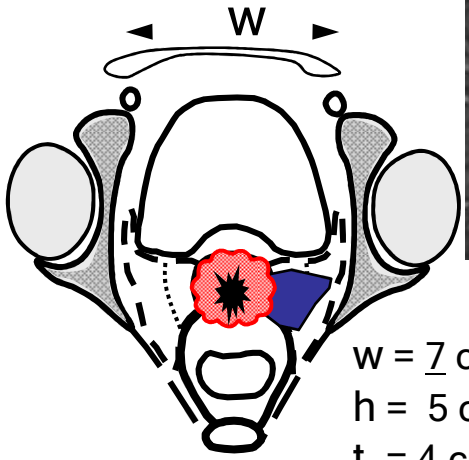


Radiotherapy and Oncology 78 (2006) 67–77

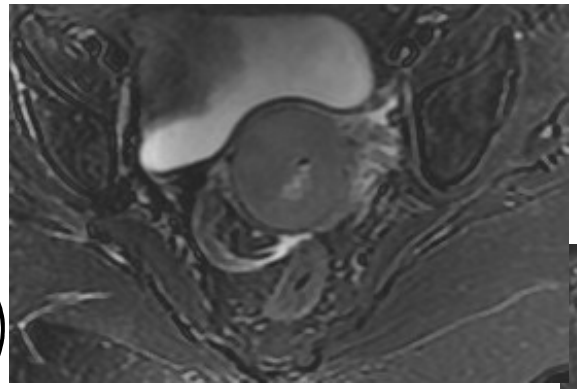
Clinical Drawing

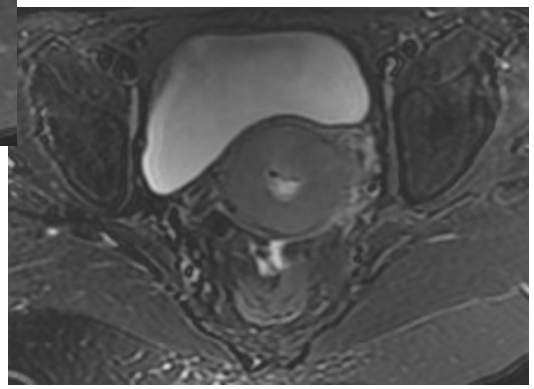
At Diagnosis

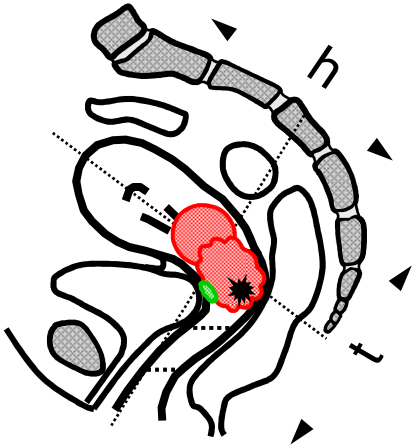


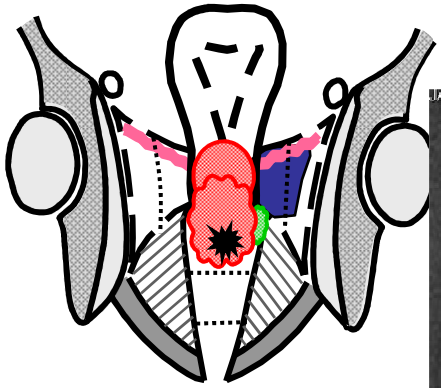


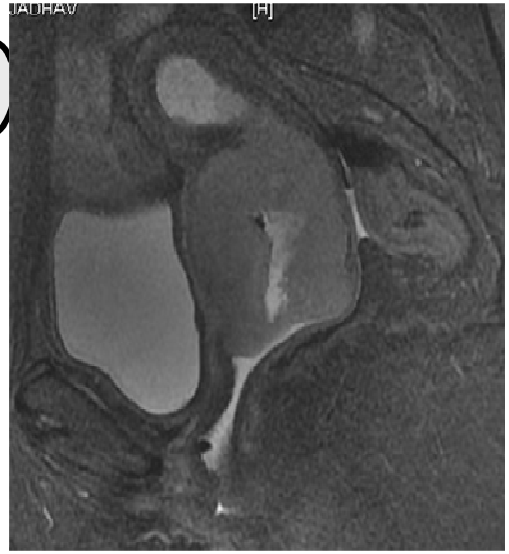
w = 7 cm
h = 5 cm
t = 4 cm

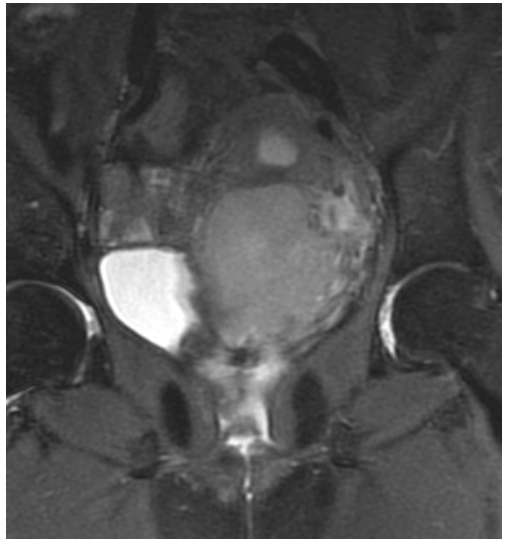




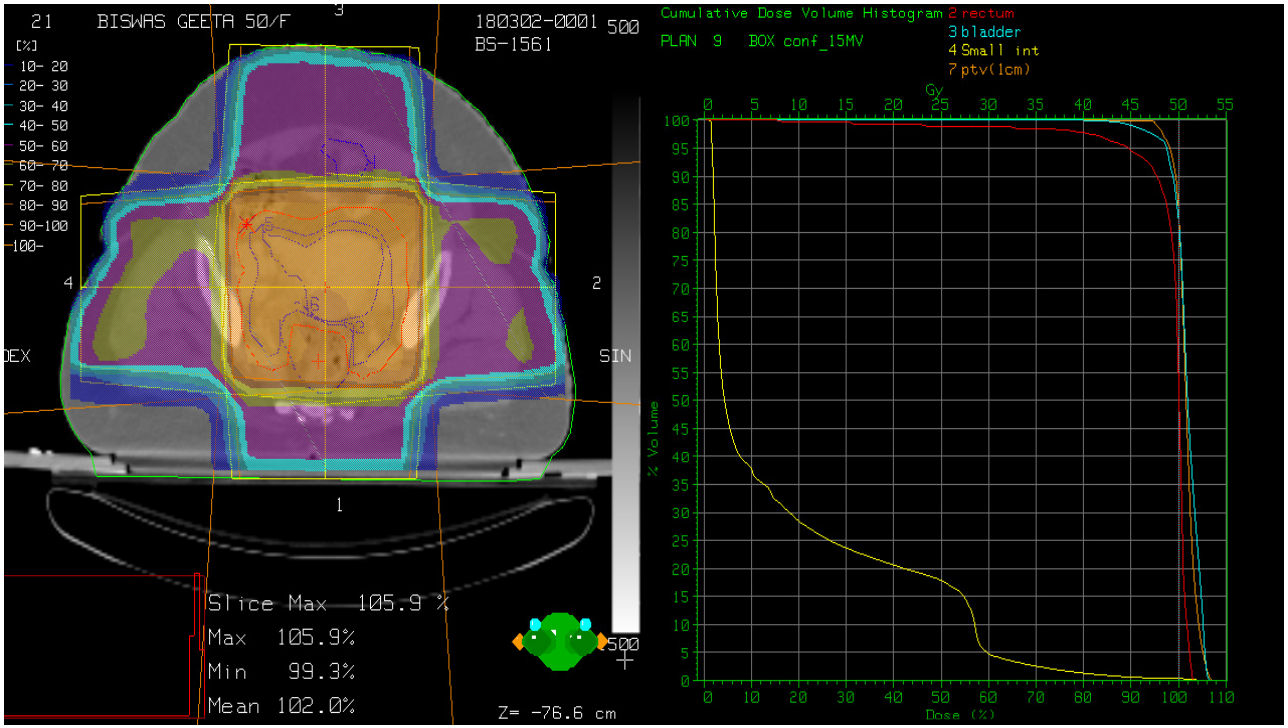






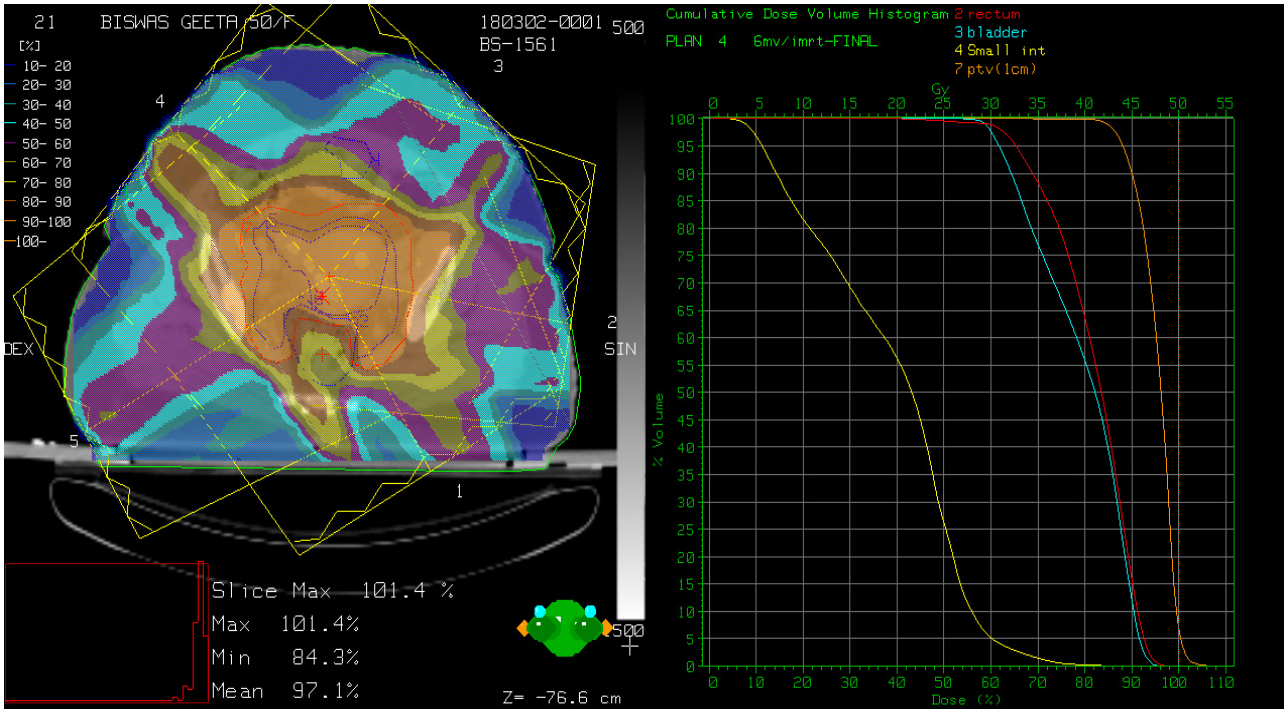


3D CRT



IMRT

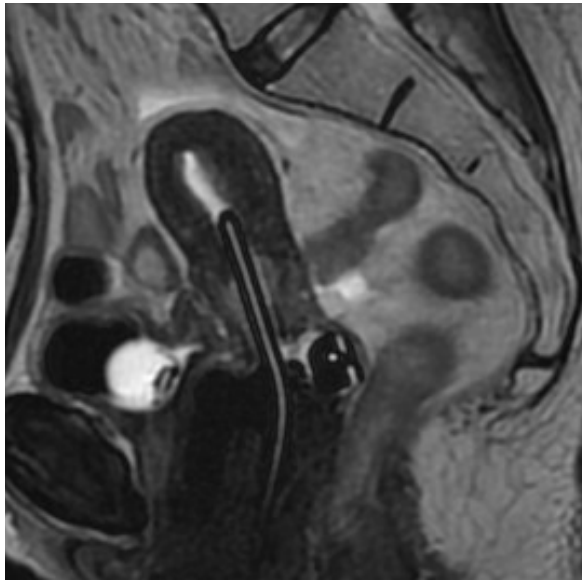
- **XRT: Pelvis**
- **3DCRT / IMRT**
- **Dose : 45 – 50 Gy**
- **Concomitant weekly Cisplatin (40 mg / m2)**
- **Assess for Brachytherapy boost**

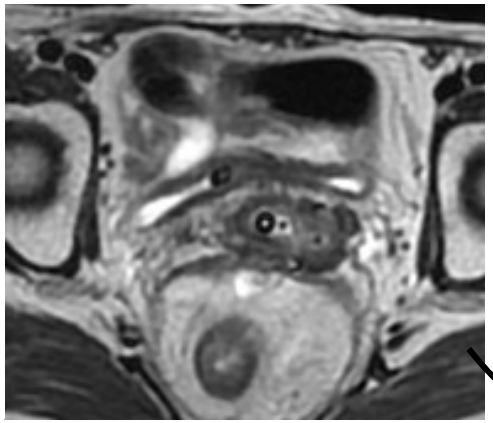


Brachytherapy Planning

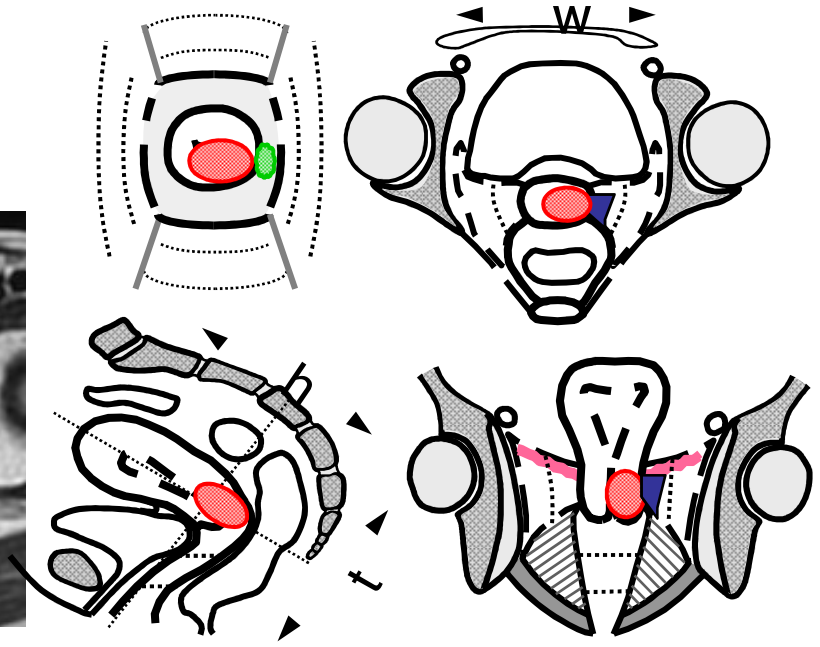
- Brachytherapy : EUA, Appropriate Applicator placement
- MR Imaging : Bladder protocol, T1 / T2 axial, sagittal, coronal (3mm with 1mm)
- Contouring : Targets and OAR's
- Planning : TPS (Brachyvision / Oncentra / Plato)
  - Catheter reconstruction
  - Loading pattern (Std with Needles ratio)
  - Optimization (Manual / Inverse)
- Plan evaluation : EQD2 values
  - Doses to HR-CTV, GTV (D90, D100, V100 etc…)
  - Doses to OAR's (rectum, bladder, sigmoid 0.1 cc, 1 cc, 2cc)

Screen shots at 1st Brachytherapy

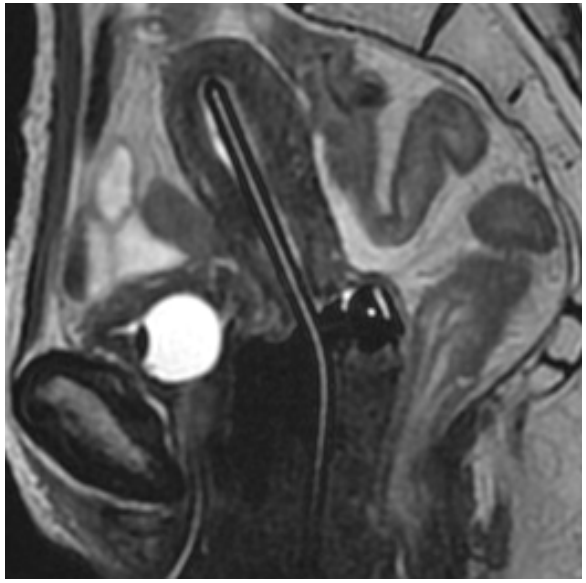


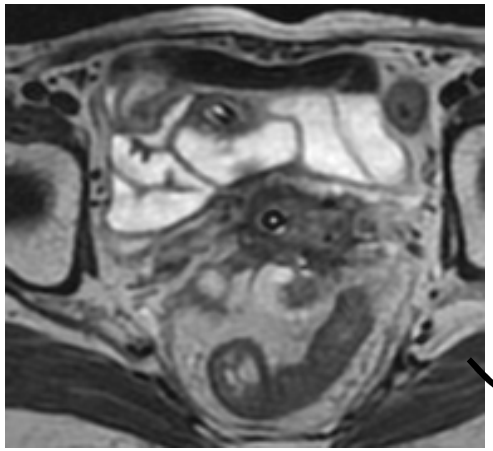


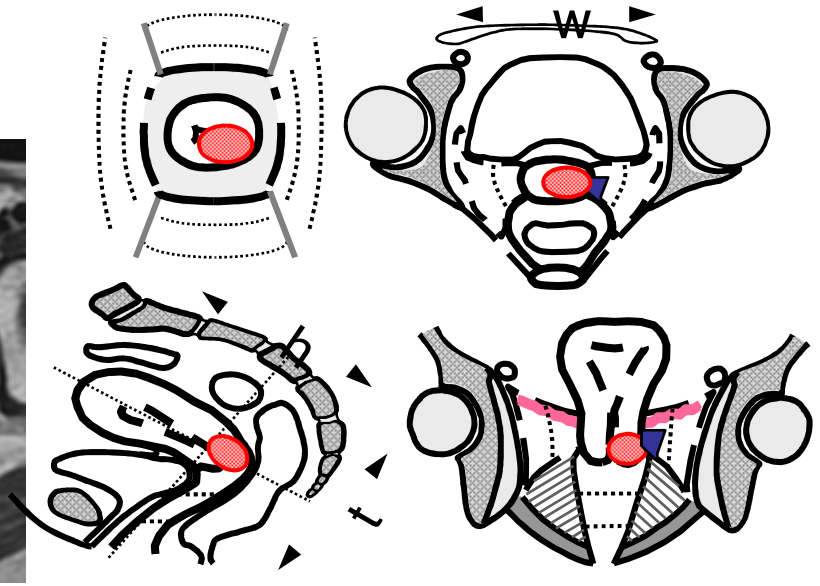
Clinical Drawing



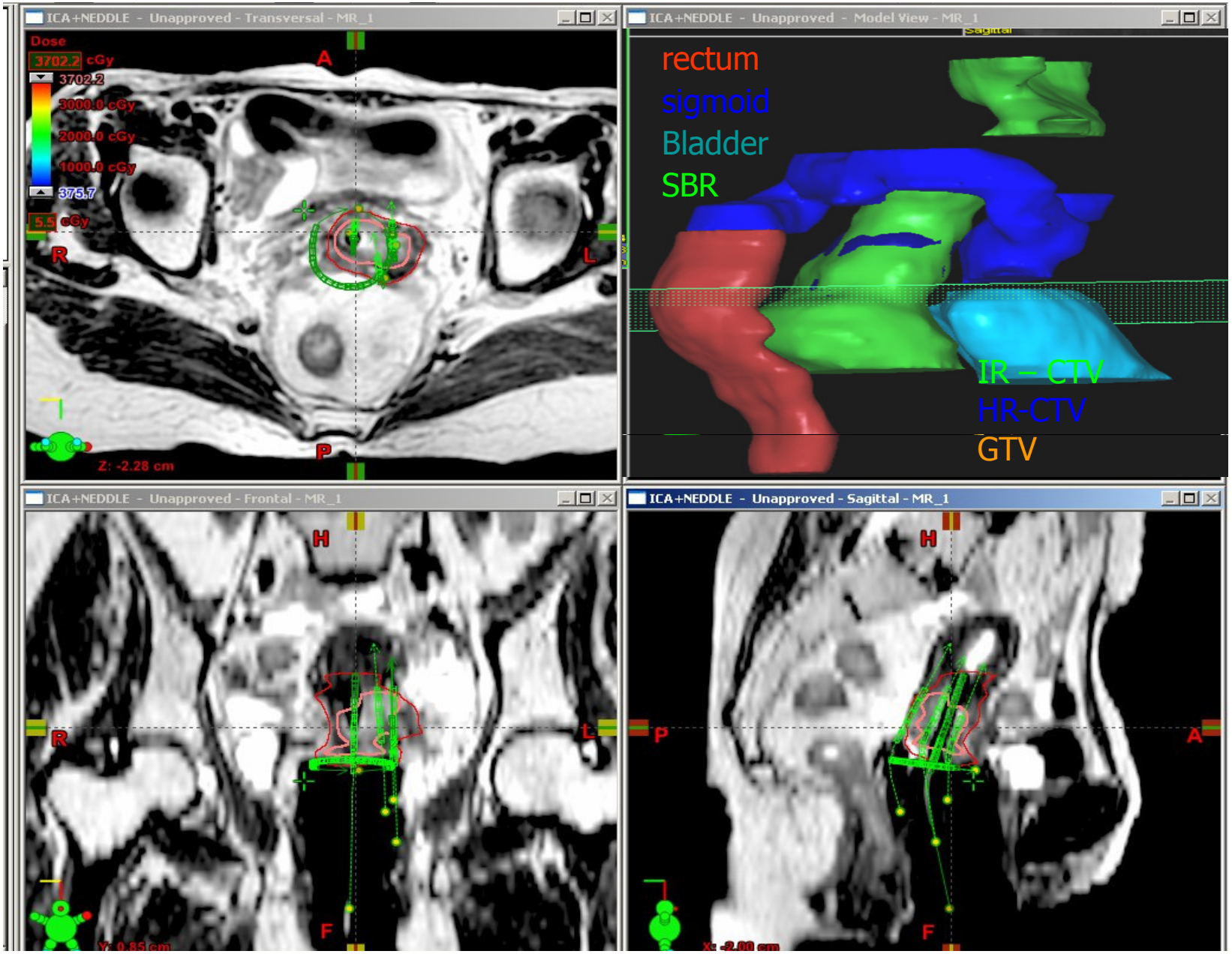
Screen shots at 2nd Brachytherapy



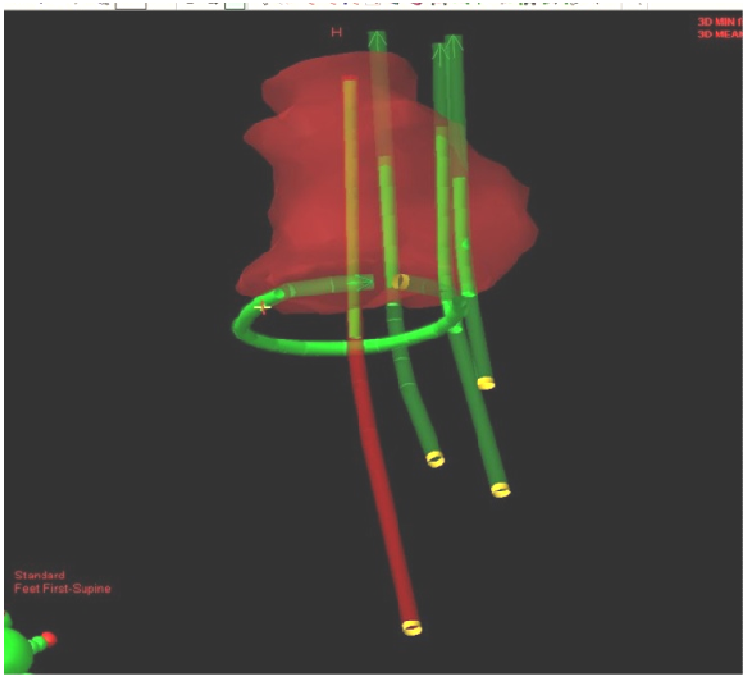


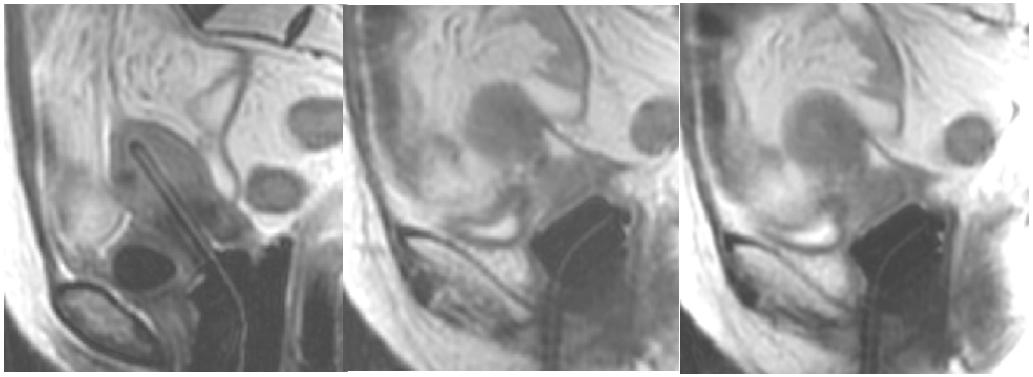


CONTOURING


ICA+NEDDLE - Unapproved - Transversal - MR_1
Dose
3702.2 cGy
3702.2
3000.0 cGy
2000.0 cGy
1000.0 cGy
375.7
5.5 cGy
A
R
L
P
Z: -2.28 cm
ICA+NEDDLE - Unapproved - Model View - MR_1
rectum
sigmoid
Bladder
SBR
IR – CTV
HR-CTV
GTV
ICA+NEDDLE - Unapproved - Frontal - MR_1
H
R
L
F
ICA+NEDDLE - Unapproved - Sagittal - MR_1
H
P
A
F

CATHETER RECONSTRUCTION

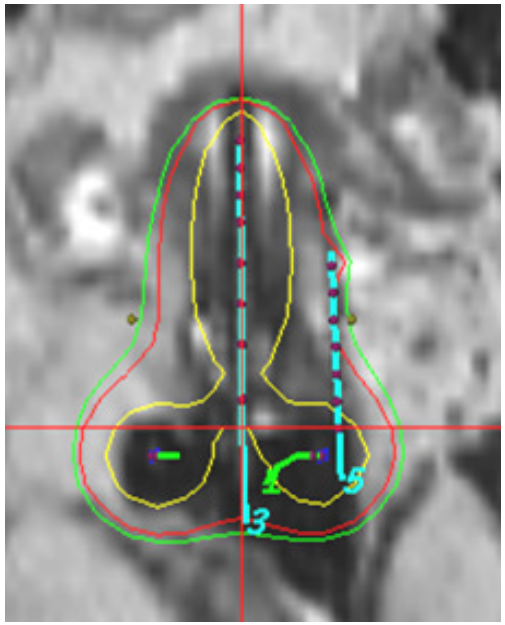


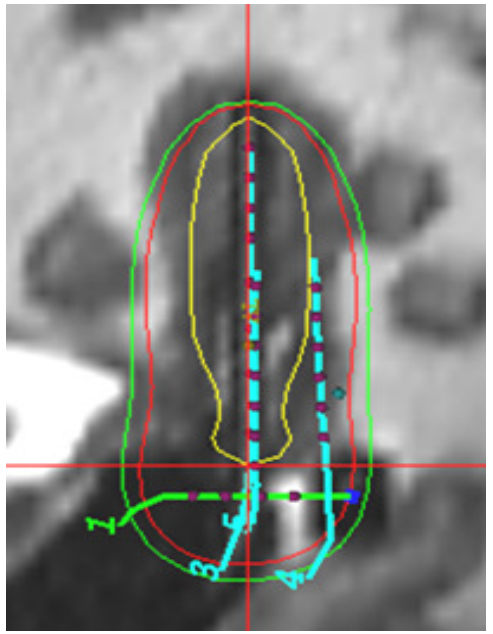


- Direct reconstruction from MR Images
- Variation < 2 mm

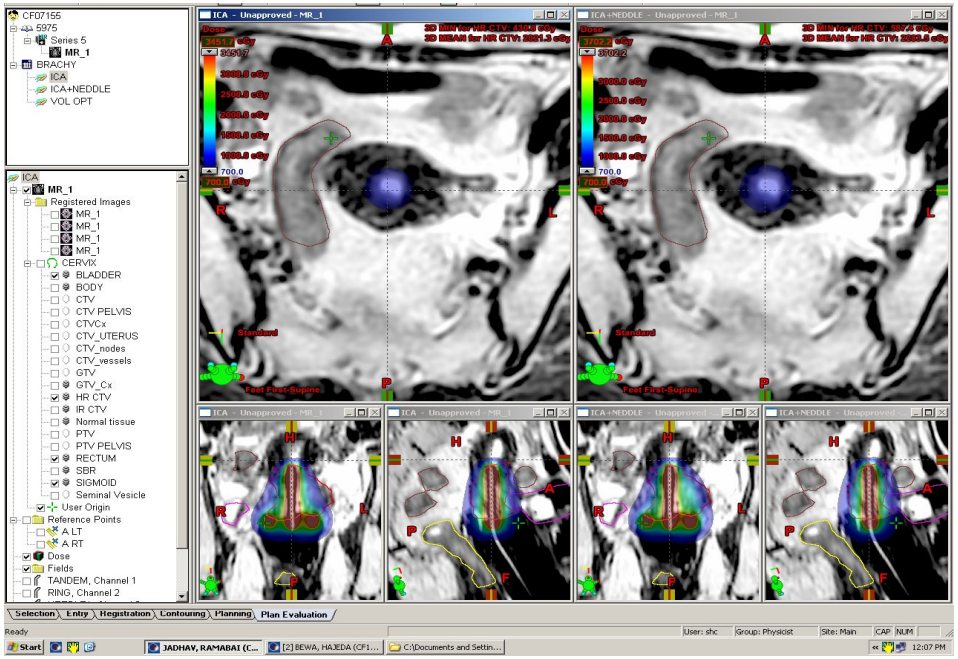
APPROPRIATE LOADING

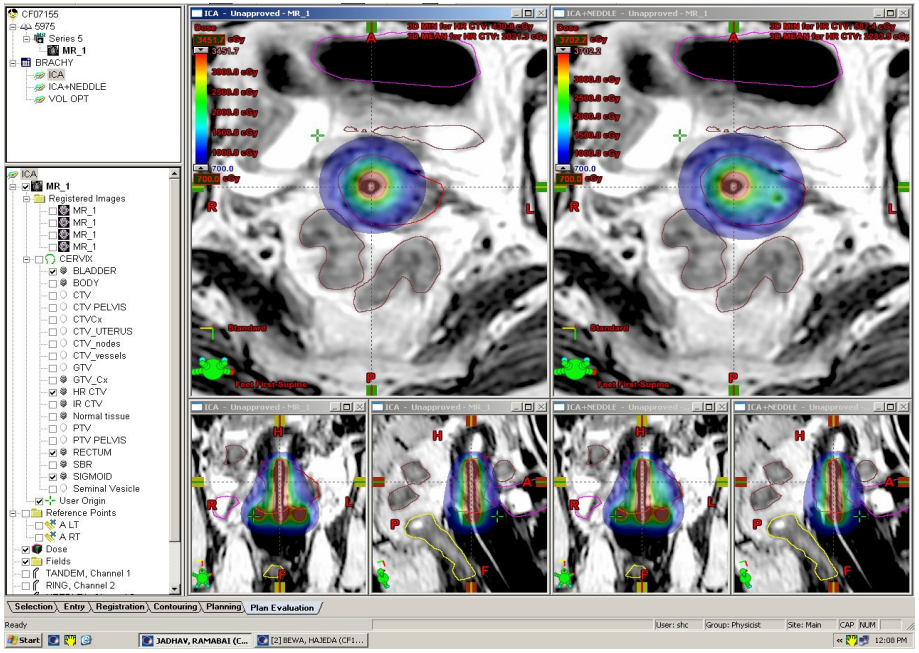
- Std ICA loading
- Load Interstitial needles

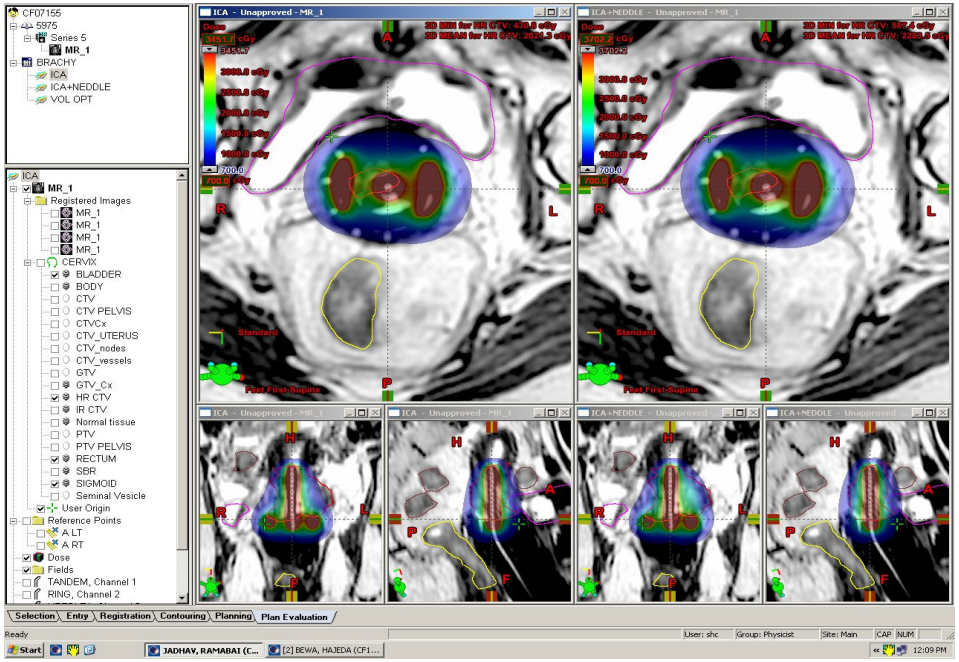


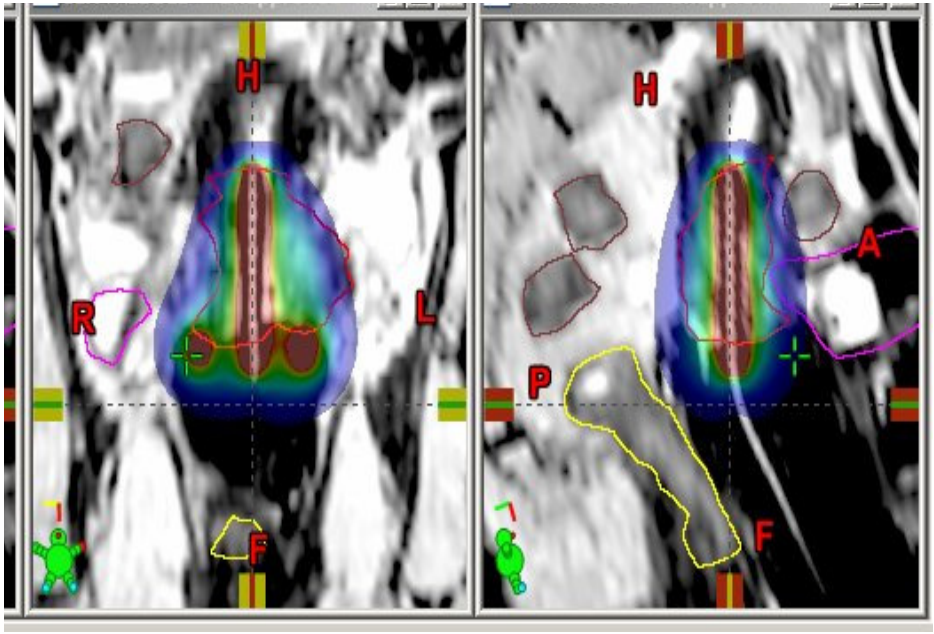


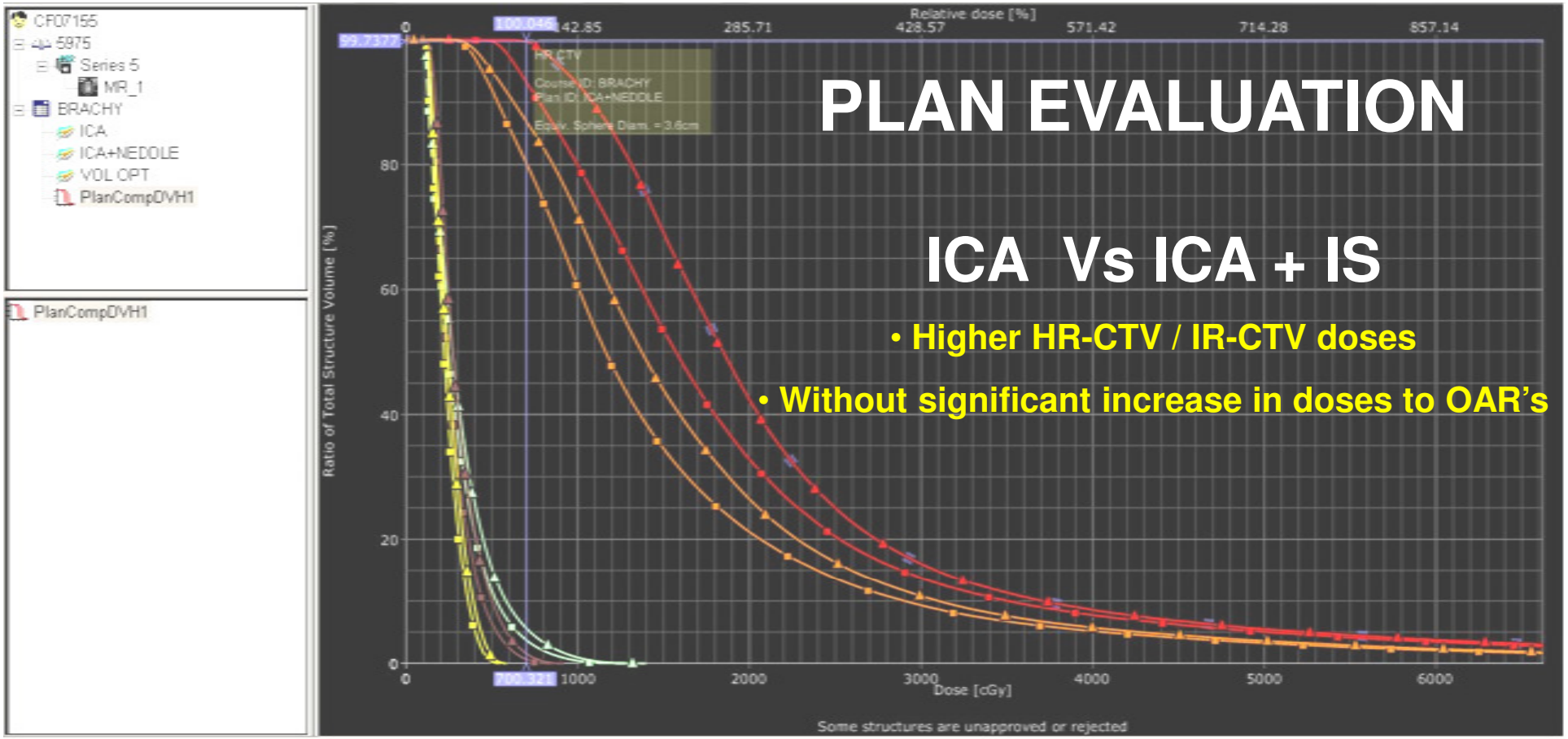
PLAN EVALUATION











Selection | Entry | Registration | Contouring | Planning | Plan Evaluation

Plan Objectives | Optimization Objectives | Dose Statistics

View	DVH Line	Structure	Approval Status	Plan	Course	Volume [cm³]	Dose Cover.[%]	Sampling Cover...	Min Dose [cGy]	Max Dose [cGy]	Mean Dose [cGy]
☑		SIGMOID	Unapproved	ICA	BRACHY	41.1	100.0	100.0	107.4	856.5	277.9
☑		SIGMOID	Unapproved	ICA+NEEDLE	BRACHY	41.1	100.0	100.0	119.3	922.2	310.0
☑		RECTUM	Unapproved	ICA	BRACHY	23.5	100.0	100.1	106.6	546.8	236.6
☑		RECTUM	Unapproved	ICA+NEEDLE	BRACHY	23.5	100.0	100.1	118.0	585.0	257.3
☑		IR CTV	Unapproved	ICA	BRACHY	48.1	100.0	100.0	239.1	40299.2	1581.9
☑		IR CTV	Unapproved	ICA+NEEDLE	BRACHY	48.1	100.0	100.0	259.0	40765.9	1765.6
☑		HR CTV	Unapproved	ICA	BRACHY	23.6	100.0	100.0	430.8	38519.5	2021.3
☑		HR CTV	Unapproved	ICA+NEEDLE	BRACHY	23.6	100.0	100.0	587.4	38979.4	2283.5
☑		BLADDER	Unapproved	ICA	BRACHY	69.8	100.0	100.0	96.3	1295.8	294.4
☑		BLADDER	Unapproved	ICA+NEEDLE	BRACHY	69.8	100.0	100.0	106.8	1406.4	324.9
☐		Whole dose matrix	Unapproved	ICA	BRACHY						

Key points

- Imaging and Contouring of Target & OAR's Protocol
- Treatment planning
  - Catheter reconstruction
  - HR-CTV Volume based Optimization (Point A based)
  - Loading patterns & optimum ratio of Std Vs Interstitial
  - Standard loading followed by manual optimization : Safe
  - Documentation of DVH Parameters
- Individualized plan for each application : to minimize inter-fraction variation
- Treatment Delivery: QA check
- Team work : Radiologist, Rad Oncologist, Med Physicist, Dosimetrist & Tech
- Small learning Curve

Results – Optimization and CTV / GTV (Vienna 1998-2003)

Mean Values for **Point A** left and right: 79 (±10) $Gy_{\alpha\beta10}$

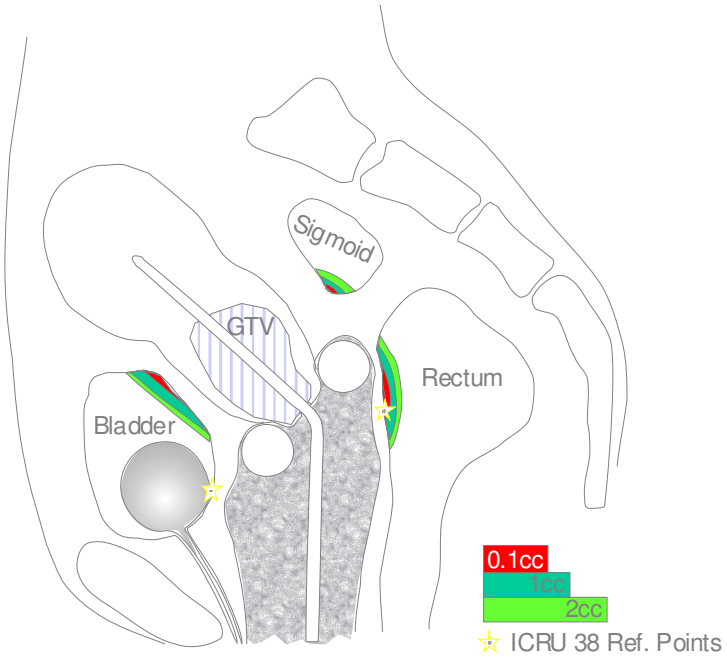
	High Risk CTV		**GTV**	
Volume	36	-	12	cm^3
D100 (minimum target dose)	65	-	90	$Gy_{\alpha\beta10}$
D90	86	-	123	$Gy_{\alpha\beta10}$
V100	87	-	97	%

Based on 145 patients with individual MRI based treatment plans
Dimopoulos et al. 2009, Pötter et al. 2007

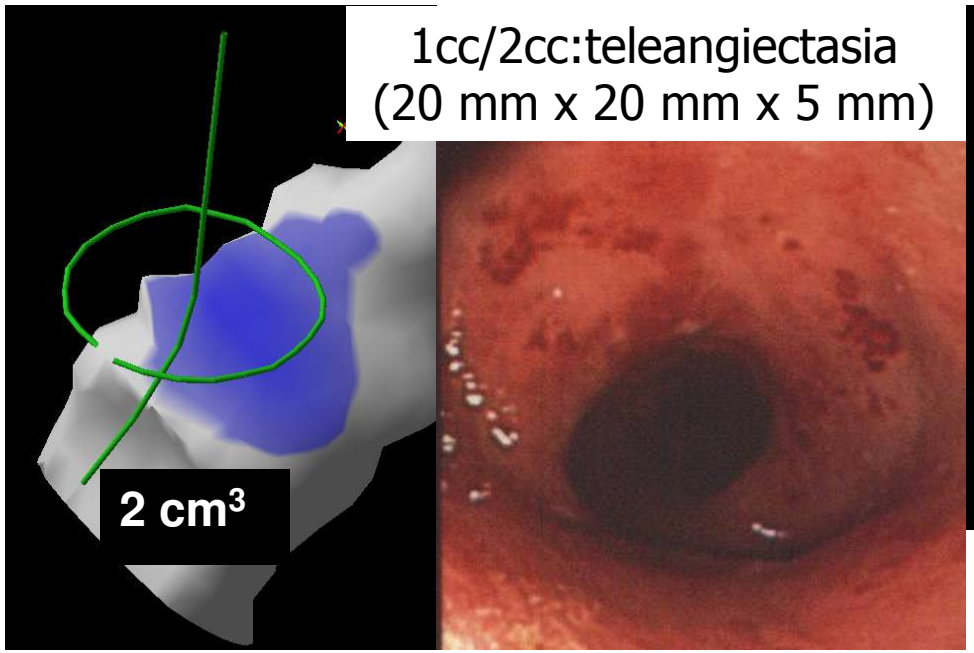
3D-based Dose Volume Parameters for OAR

CLASSICAL MAX DOSE : in 3D
no clinical relevant endpoint

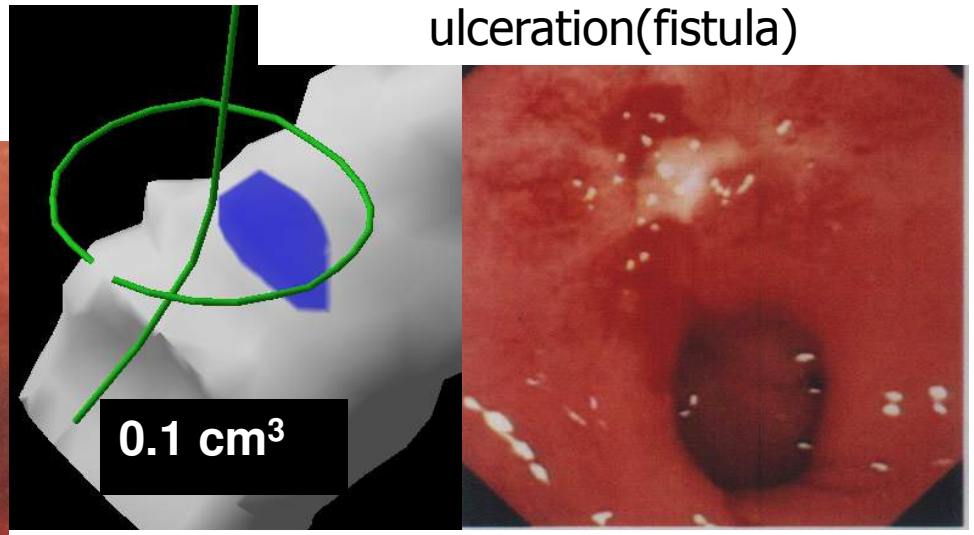
FIXED VOLUME: tolerance dose (total dose)-
"minimum dose to the most exposed tissue"*



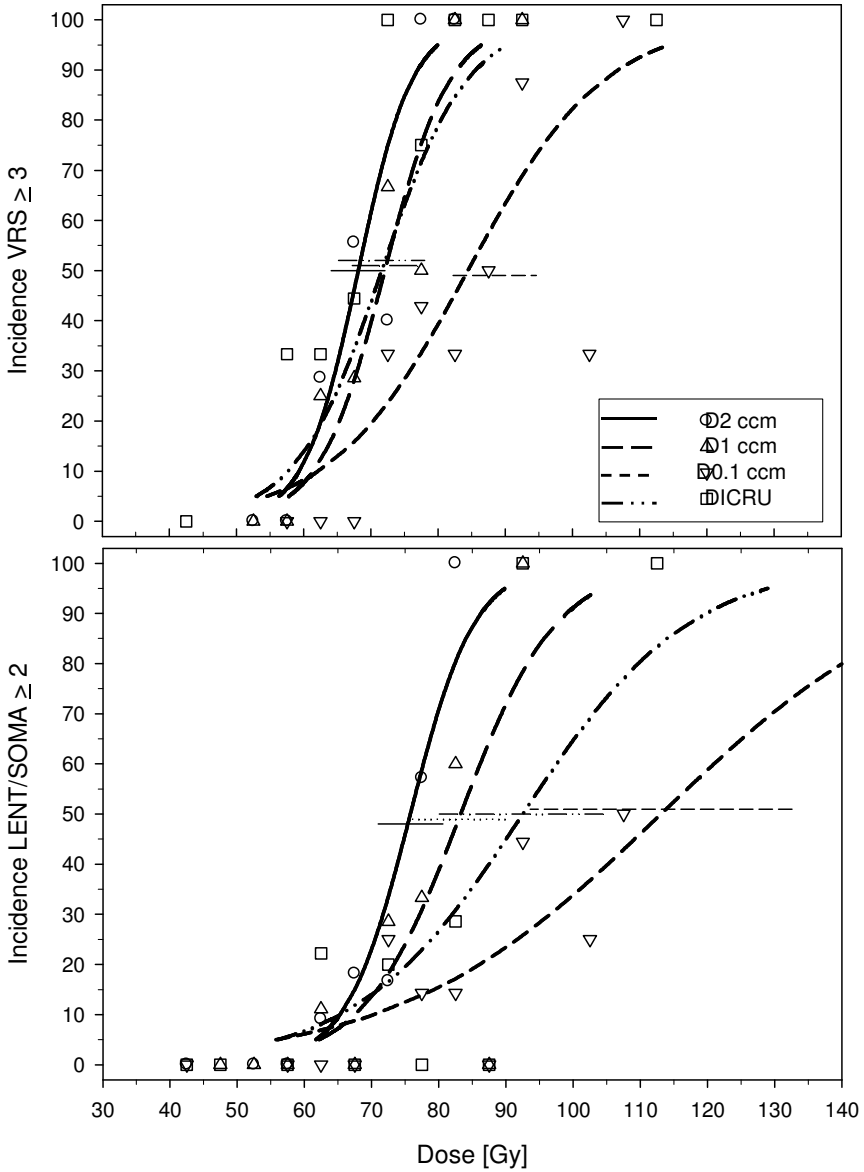
1cc/2cc:teleangiectasia
(20 mm x 20 mm x 5 mm)



0.1 cc: 3D"maximum dose":
ulceration(fistula)



*GYN GEC ESTRO Recommendations(II) Radiother Oncol 2006



P. Georg et al. Radioth&Oncol 2009

Koom et al. IJROBP 2007

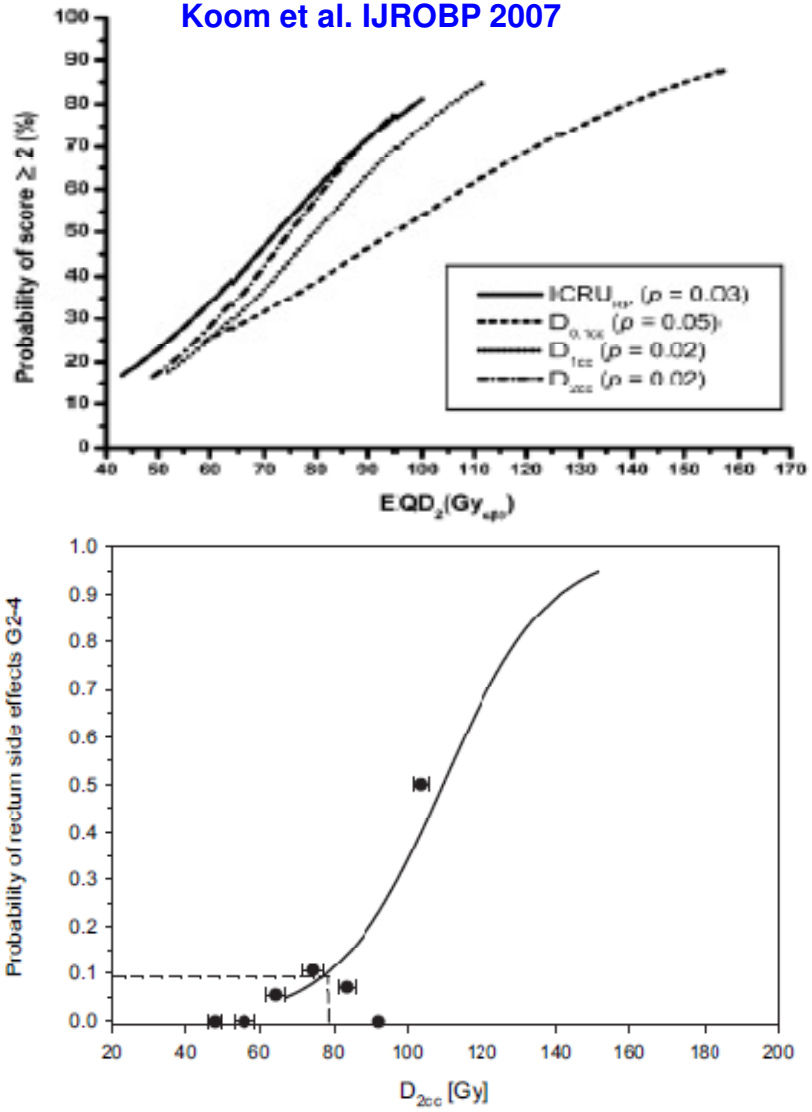


Fig. 1. Relationship between D_{2cc} and late side effects in the rectum.

P. Georg et al. IJROBP 2011

Results – DVH values / ICRU reference points

Bladder	
D_{2cc}	95 (±22) $Gy_{\alpha\beta3}$
$D_{0.1cc}$	162 (±75) $Gy_{\alpha\beta3}$
ICRU point dose	72 (±15) $Gy_{\alpha\beta3}$
Rectum	
D_{2cc}	65 (±12) $Gy_{\alpha\beta3}$
$D_{0.1cc}$	86 (±27) $Gy_{\alpha\beta3}$
ICRU point	67 (±13) $Gy_{\alpha\beta3}$
Sigmoid	
D_{2cc}	62 (±12) $Gy_{\alpha\beta3}$
$D_{0.1cc}$	78 (±12) $Gy_{\alpha\beta3}$

Biologically weighted to 2 Gy/fraction, α/β=3 Gy

Based on 145 patients with individual MRI based treatment plans (Vienna) (Georg et al. 2011 IJROBP)

EVIDENCE

TMH Data (Dec 2006 - May 2008)
(N = 24)

Total no of patients	**24**
Median Age (range)	**45 (35-65) years**
Histology	**Squamous Carcinoma**
FIGO Stage (n)	**24**
IB2/IIA	**2**
IIB	**10**
IIIB	**12**
Intracavitary Brachytherapy (HDR)	**3-5 fractions of 7 Gy to point A once weekly**
Median follow-Up (Range)	**18 (12 – 40) months**

Mahantshetty et al, IJGC Aug. 2011

	Vienna IC IJROBP2005	Vienna IC/IS IJROBP2005	Brabandere RO 2008	Lindegaard IJROBP2008	Chargari IJROBP 2008	TMH study IJGC 2011
HRCTV						
Vol in cc	34 +/- 17	44 +/- 27	48+/-19	34+/- 12	36.3±35	**45.2 ± 15.8**
D100	66 +/- 7	70 +/- 6	64+/-6	76 +/- 7	61.66±7	**53.9 ± 6.5**
D90	87 +/-10	96 +/- 12	79+/-7	91 +/- 10	74.85±10	**70.3 ± 10.6**
Avg. Pt A	89 +/- 8	93 +/- 9	79+/-5	92 +/- 9	71.4±6	**73.4 ± 4.5**
Bladder						
Vol in cc	--	--		--		**80.3 (20.3-235)**
ICRU Bmax	75 +/-16	73 +/- 19	74+/-15	67 +/- 31	63.7±9	**80.4 ± 34.4**
D0.1cc	121+/-25	113+/- 30	100+/-12	86 +/- 45	87.6±12	**136.0 ± 54.7**
D2cc	83 +/-9	83 +/-14	82+/-6	73 +/- 16	71.7±6	**91.4 ± 24.6**
Rectum						
Vol cc	--	--		--		**33.4 (11-64.6)**
ICRU Rmax	69 +/- 13	71 +/- 13	66+/-9	71 +/- 5	67.3±8	**63.5 ± 8.1**
D0.1cc	77 +/- 10	77 +/- 9	64+/-5	71 +/- 10	70.6±11	**67.2 ± 9.9**
D2cc	64+/- 6	66 +/- 6	66+/-9	61 +/- 6	67.3±8	**57.9 ± 7.7**
Sigmoid						
Vol cc	--	--		--		**49.0 (14.5-97.5)**
D0.1cc	79 +/- 12	84 +/- 14	82+/-13	79 +/- 13	72.7±18	**101.9 ± 45.2**
D2cc	63 +/- 7	67 +/- 7	68+/-7	69 +/- 9	60.6±6	**74.4 ± 19.6**

Dosimteric Outcome

Mahantshetty et al, IJGC Aug. 2011

	Vienna IC IJROBP2005	Vienna IC/IS IJROBP2005	Brabandere RO 2008	Lindegaard IJROBP2008	Chargari IJROBP 2008	TMH Study Mean ± S.D
HRCTV						
Vol in cc	34 +/- 17	44 +/- 27	48+/-19	34+/- 12	36.3±35	**45.2 ± 15.8**
D100	66 +/- 7	70 +/- 6	64+/-6	76 +/- 7	61.66±7	**53.9 ± 6.5**
D90	87 +/-10	96 +/- 12	79+/-7	91 +/- 10	74.85±10	**70.3 ± 10.6**
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Bladder						
Vol in cc	--	--		--		**80.3 (20.3-235)**
ICRU Bmax	75 +/-16	73 +/- 19	74+/-15	67 +/- 31	63.7±9	**80.4 ± 34.4**
D0.1cc	121+/-25	113+/- 30	100+/-12	86 +/- 45	87.6±12	**136.0 ± 54.7**
D2cc	83 +/-9	83 +/-14	82+/-6	73 +/- 16	71.7±6	**91.4 ± 24.6**
Rectum						
Vol cc						**(11-64.6)**
ICRU Rma						**± 8.1**
D0.1cc						**± 9.9**
D2cc	64+/- 6	66 +/- 6	66+/-9	61 +/- 6	67.3±8	**57.9 ± 7.7**
Sigmoid						
Vol cc	--	--		--		**49.0 (14.5-97.5)**
D0.1cc	79 +/- 12	84 +/- 14	82+/-13	79 +/- 13	72.7±18	**101.9 ± 45.2**
D2cc	63 +/- 7	67 +/- 7	68+/-7	69 +/- 9	60.6±6	**74.4 ± 19.6**

- **HR CTV volumes higher**
- **Sigmoid and Bladder Doses higher**

EVIDENCE

TMH Data (Dec 2006 - May 2008) (N = 24)

Median Follow-up : 18 (12 - 40) months

Treatment Outcome

	Stage			
	I B2 / IIA N=2	IIB N=10	IIIB N=12	Total N=24
Local	--	2*	1#	3
Pelvic Node	--	--	1	1
Dist. metastasis	--		1	1
Total	--	2	3	5

* Point A: 79 Gy and HR-CTV D90 doses : 56.5, 67 Gy;

Point A: 70 Gy and HR-CTV D90 doses : 65Gy;

Late sequelae: 1 pt with protco-sigmoiditis

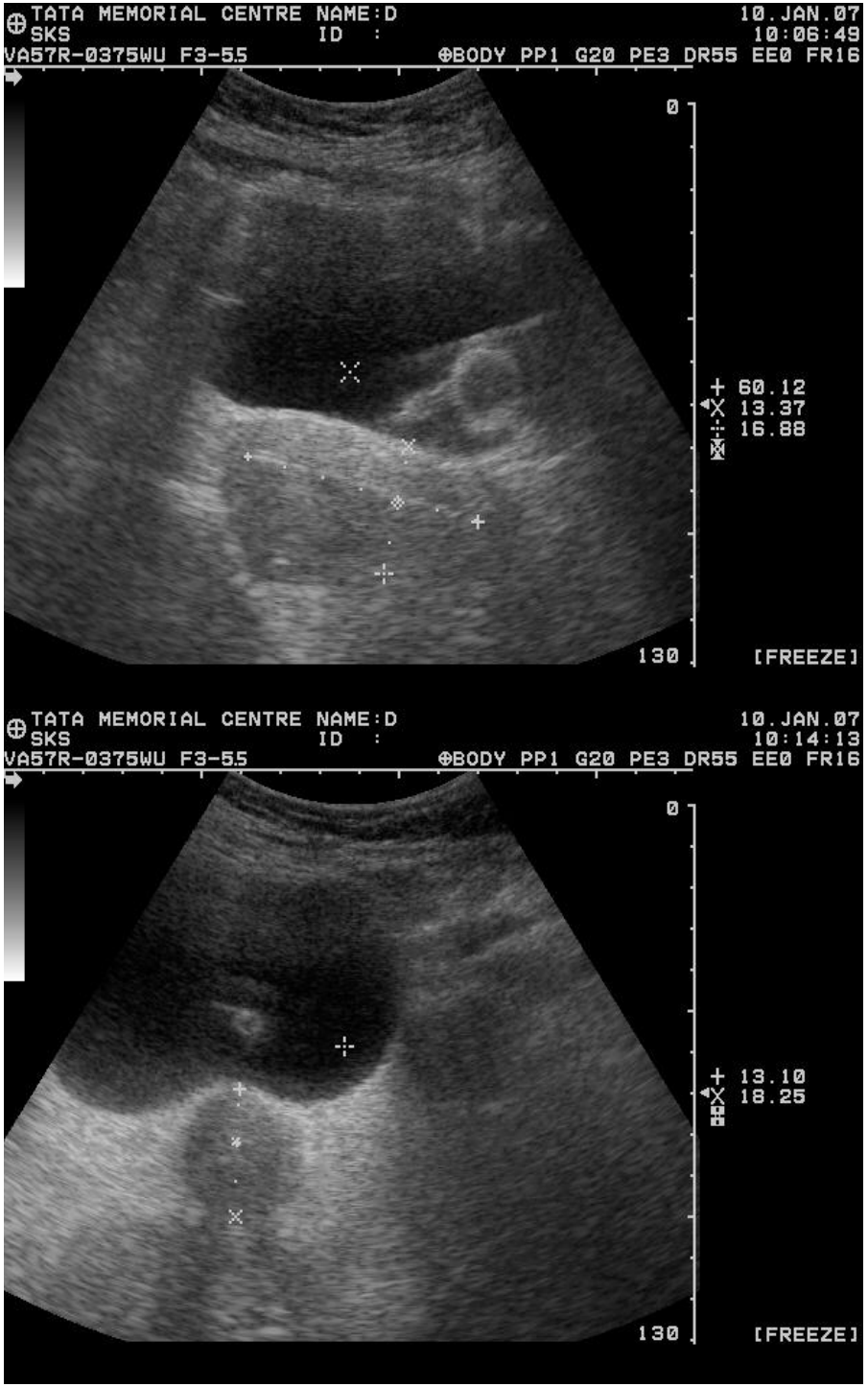
(0.1 and 2cc : R 46 & 64; S: 140 & 260 Gy))

Mahantshetty et al, Clin. Oncol. 2011 ; IJGC Aug. 2011

CLINICAL OUTCOME	Vienna# N = 145	Paris ♦ N = 45	TMH$ N = 24
FIGO Stage	I-IVA	IB-IVA	IB2-IIIB
ICA/IS	HDR	PDR	HDR
Median Follow-up (Range) in mths	51	26 (9-47)	12 (6-36)
Local Control Rates	**87.5%**	**100***	**91.5%**
Loco-regional Control Rates	**86%**	**95%**	**87.5%**
Rectal/Sigmoid late sequelae **(G3-4)**	4%	7%	<1% so far
Bladder late sequelae (G3-4)	4%	8% (VVF)	--

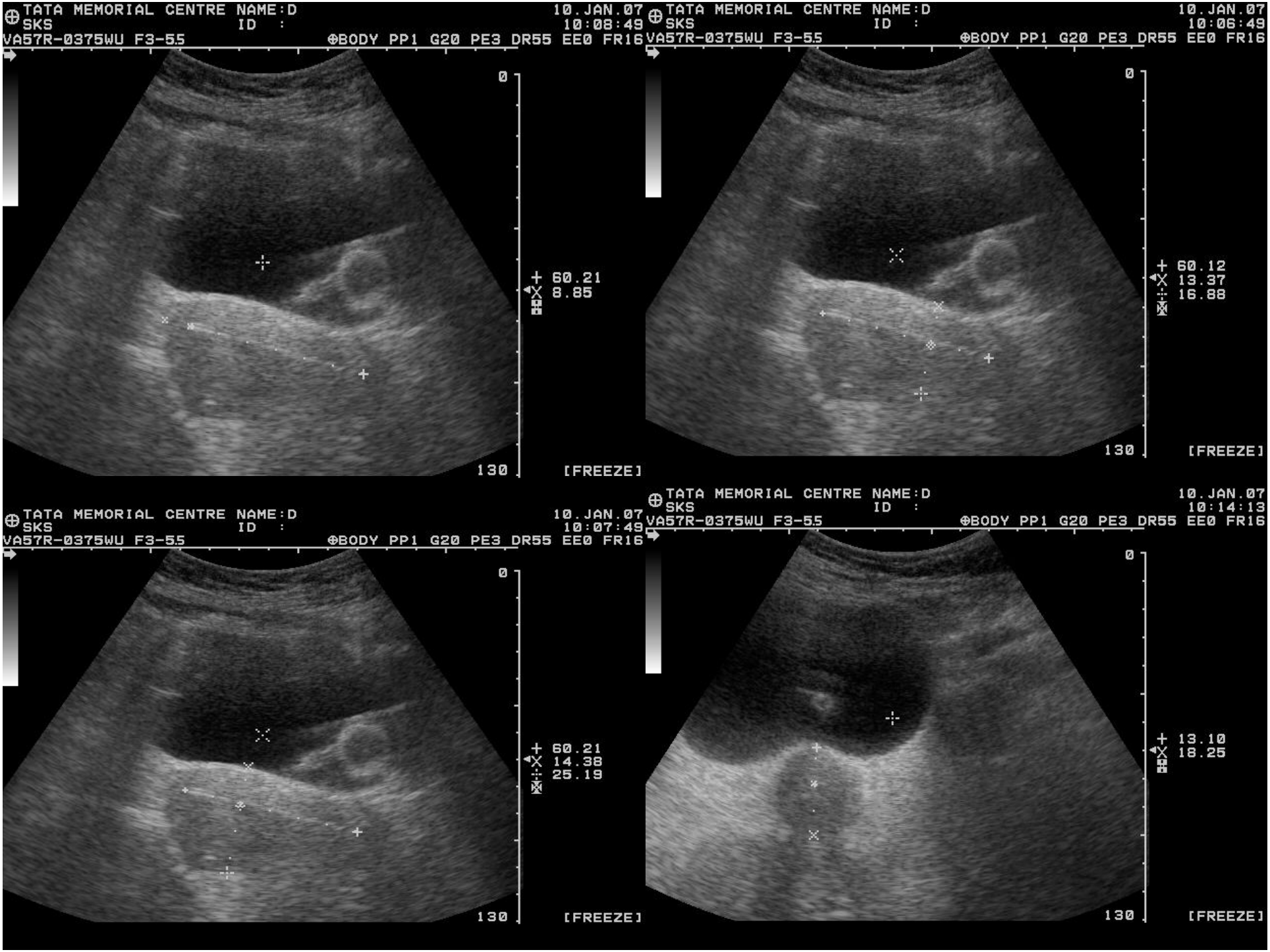
**** 26/45 patients underwent hysterectomy***

 # RO 2007; ♦ IJROBP 2008; $ ***IJGC Aug. 2011***



US in Cx Brachytherapy

- Ultrasound guided insertion of central tandem
  - Tandem length
  - Retroverted uterus
  - False passage
- Ultrasound based planning
  - Uterine wall thickness
  - Bladder points
  - Rectal points
- Drawbacks
  - Coronal imaging not available
  - Posterior uterine surface not visible well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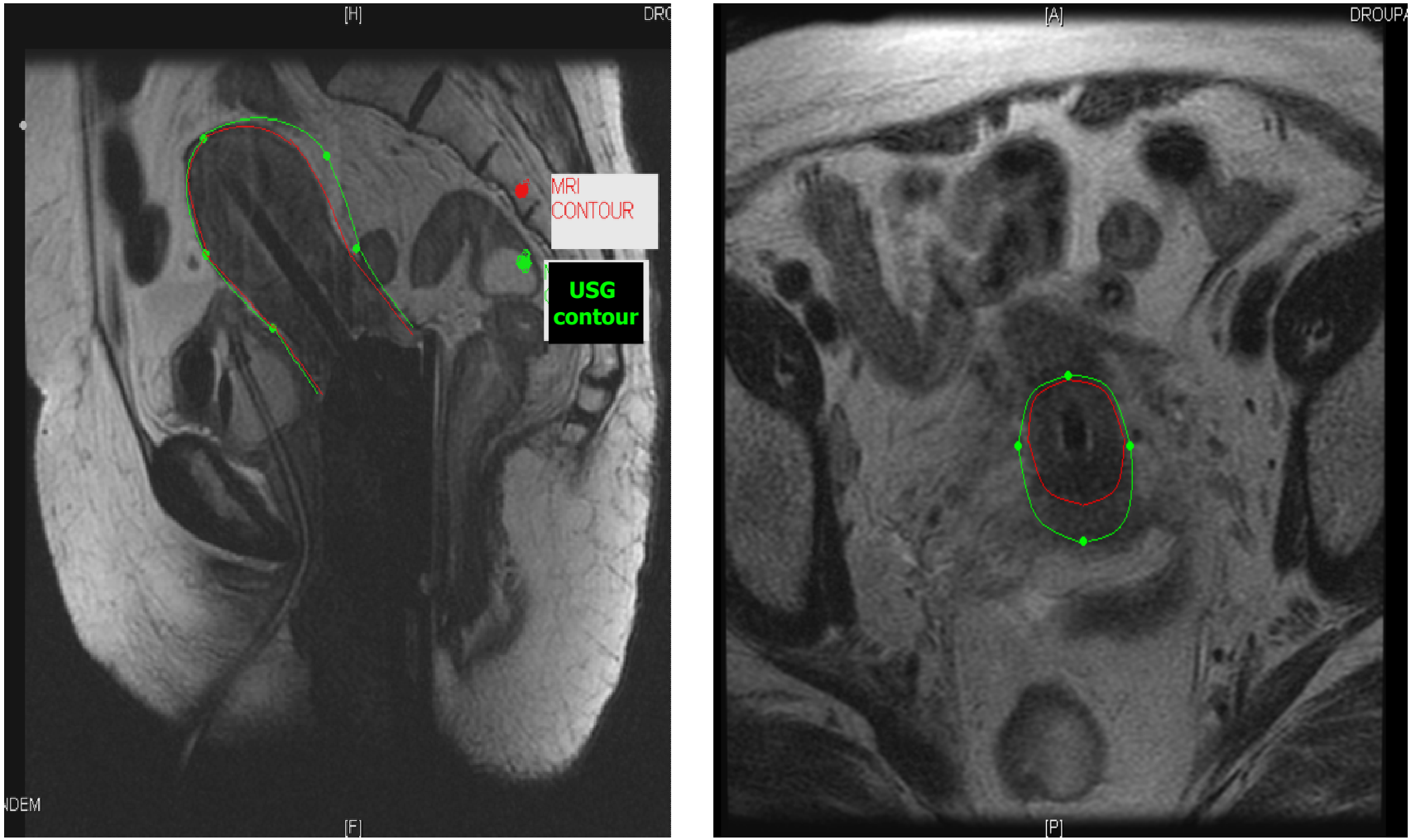
SKS ID :
10.JAN.07
10:08:49
VA57R-0375WU F3-5.5
⊕BODY PP1 G20 PE3 DR55 EE0 FR16
0
60.21
8.85
130
[FREEZE]
TATA MEMORIAL CENTRE NAME:D
SKS ID :
10.JAN.07
10:06:49
VA57R-0375WU F3-5.5
⊕BODY PP1 G20 PE3 DR55 EE0 FR16
0
60.12
13.37
16.88
130
[FREEZE]
TATA MEMORIAL CENTRE NAME:D
SKS ID :
10.JAN.07
10:07:49
VA57R-0375WU F3-5.5
⊕BODY PP1 G20 PE3 DR55 EE0 FR16
0
60.21
14.38
25.19
130
[FREEZE]
TATA MEMORIAL CENTRE NAME:D
SKS ID :
10.JAN.07
10:14:13
VA57R-0375WU F3-5.5
⊕BODY PP1 G20 PE3 DR55 EE0 FR16
0
13.10
18.25
130
[FREEZE]

Extrapolation of USG contour over MRI



Mahantshetty et al. Rad. Oncol. Aug. 2011

USG and MRI correlation (TMH data)

- 32 Applications with MRI Compatible Applicator
- Anterior Reference Points : 96 %
- Posterior Reference Points : 72 %
- Magnitude of Variation (>15%) : < 8%

Significant Correlation between the USG and MRI Reference Points

Suggest : Use of USG for ICA Planning (21/2 D Planning)

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ELSEVIER FULL-TEXT ARTICLE

Int J Radiat Oncol Biol Phys. 2009 Sep 1;75(1):64-70. Epub 2009 Feb 26.

Conformal brachytherapy planning for cervical cancer using transabdominal ultrasound.

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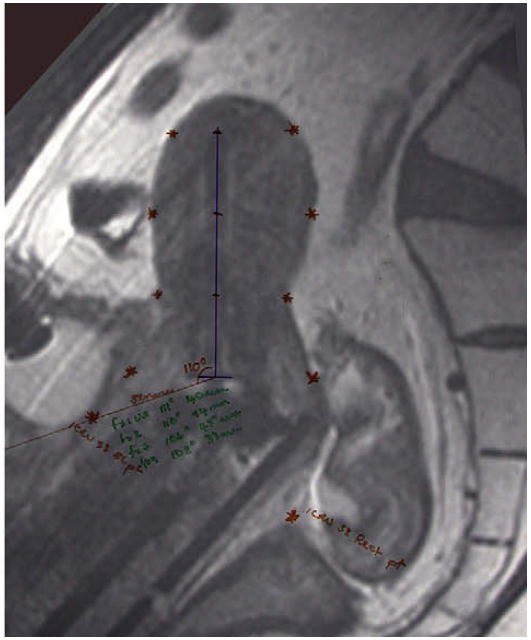
Abstract

PURPOSE: To determine if transabdominal ultrasound (US) can be used for conformal brachytherapy in cervical cancer patients.

MATERIALS AND METHODS: Seventy-one patients with locoregionally advanced cervix cancer treated with chemoradiation and brachytherapy were included in this study. The protocol consisted of US-assisted tandem insertion and conformal US-based planning. Orthogonal films for applicator reconstruction were also taken. A standard plan was modified to suit the US-based volume and treatment was delivered. The patient then underwent a magnetic resonance imaging (MRI) scan with the applicators in situ. Retrospectively, individual standard (STD), US, and MRI plans were extrapolated for five fractions and superimposed onto the two-dimensional sagittal MRI images for comparison. Doses to Point A, target volume, International Commission on Radiation Units and Measurements (ICRU) 38 bladder and rectal points, and individualized bowel points were calculated on original implant geometry on Plato for each planning method.

RESULTS: STD (high-dose-rate) plans reported higher doses to Point A, target volume, ICRU 38 bladder and rectal points, and individualized bowel point compared with US and MRI plans. There was a statistically significant difference between standard plans and image-based plans-STD vs. US, STD vs. MRI, and STD vs. Final-having consistent ($p \leq 0.001$) respectively for target volume, Point A, ICRU 38 bladder, and bowel point. US plan assessed on two-dimensional MRI image was comparable for target volume ($p = 0.11$), rectal point ($p = 0.8$), and vaginal mucosa ($p = 0.19$). Local control was 90%. Late bowel morbidity (G3, G4) was <2%.

CONCLUSIONS: Transabdominal ultrasound offers an accurate, quick, accessible, and cost-effective method of conformal brachytherapy planning.



Conclusions:Transabdominal US offers accurate, quick and cost-effective method of conformal brachytherapy planning

Int. J. Radiation Oncology Biol. Phys., Vol. 75, No. 1, pp. 64–70, 2009

SUMMARY AND CONCLUSION

- **Brachytherapy should be integral part of Radical radiation therapy**
- **Conventional planning, though time tested, merits refinement**
  - **Incorporation of better Imaging**
  - **Optimization in planning including contouring**
  - **Documentation and uniform reporting**
- **Generate robust data with the above : CT Vs MR Based brachytherapy**
- **MR Image Guided Brachytherapy: Initial experience enterprising**
- **Outcome study : EMBRACE Study**
- **Use of US: Potential in our settings, needs further evaluation**
- ***Strengthen Brachytherapy skills : "Improved Therapeutic Window"***

Future Directions

- Further refinement of Applicators
- Advances in Treatment Planning: Cumulative Doses,
- Radiobiological modeling for tumor and OAR's
- Multifunctional MRI, Perfusion - diffusion regions and dose escalation

Acknowledgements :

- ***Departments of Radiation Oncology & Medical Physics***
- ***GYN Disease Management Group TMC***
- ***Patients***