Good Afternoon I am Bulent Aydogan and I will be presenting Brachytherapy with focus on Gynecological Cancers
Disclosure

I have no conflicts of interest to disclose.

I have nothing to disclose
Learning Objectives

• 1-To review brachytherapy physics
• 2-To discuss the latest updates and technical approaches to management of gynecological cancers
• 3-To overview image guided brachytherapy application including GEC-ESTRO guidelines for the treatment of gyn cancers
Pre-test Question

Which one is not correct regarding the Point A?

A. Does not relate to the tumor volume
B. Different centers use different definitions and geometric locations for point A
C. ICRU #38 recommends reporting dose to the point A
D. Depends on the applicator and source position
Survey

Which of the following imaging modalities do you use for cervical brachytherapy?

A. Film
B. CT
C. MR

Now Is the Quiz time
Survey

Which of the following do you use to prescribe treatment to?

A. Point A
B. Volume
C. Both
D. Mg-h
Survey

Which one of the following do you use for OAR dose specification?

A. ICRU guidelines
B. DVH
C. Both
Brachtheray has a long history in the treatment of GYN cancers. As a matter of fact the first **intracavitary insertion of a radium tube** was carried out soon after the discovery of radium in 1904 by Margaret Cleaves.

By 1920 radium-therapy had displaced surgery as the preferred treatment for gynecologic malignancy.
Brachytherapy in GYN can be categorized by the method by which we place sources as intracavitary or interstitial.

Under dose as LDR, PDR, and HDR.

And

Under the origin of disease

As cervical, Cervix, Endometrial, uterine, vaginal carcinoma.

As you may appreciate each one of these would take more than one hour lecture. Therefore, my talk today will focus more on general brachtherapy physics such as dosimetry, role of imaging and image guidance particularly for cervical cancers as well as recent recommendations and guidelines by GEC-ESTRO.

Low dose rate (LDR)

0.4 to 2 Gy/hr

Medium dose rate (MDR)
I would like to start with a short overview of the dosimetric systems and their shortcomings.

Different dosimetric systems evolved to more accurately prescribe the dose in GYN BT.

Stockholm and Paris are both prescribed treatment as mg-h.

We are used to see evaluate plan using absorbed dose in tissue represented by isodose line.s. As shown in this Stockholm system based treatment isodose lines are replaced by mg-h lines.

**No absorbed dose concept**

When used in adjuvant setting overall radiation cannot be defined accurately.
Manchester system established by Patterson and Parker is still the basis of most current brachy systems and practices today. As originally described, the Manchester technique introduced a radium loading system designed to deliver a homogeneous dose distribution in Roentgens/h to a defined zone of tissue, known as the paracervical triangle.

Dose prescription and implant duration are based on evaluating dose rates at

- Point A where uterine vessels cross the ureter
- Point B as a surrogate for LN
- Bladder and Rectum (<80% of point A)
Original Point A is geometrically defined from the surface of the colpostat, however, it was not easy to see it on radiograph as such later it was defined from the lowest point of the source or cervivcal os by tod and meredith 1953

Point B was suggested to represent the dose delivered to the obturator lymph node, often the first echelon of metastatic spread
because the exact meaning and its geometric location have not always been interpreted in the same way in different centers and even in the same center over a period of time.

The different methods of its definition resulted in different values for the calculated dose rate to point A consequently different values of time will be obtained for different methods used to assign the prescription point causing different dose delivered for patients with similar anatomy and disease.
ICRU Rectal Point

ICRU #38 (1985)
ICRU Bladder Point Location

Location of ICRU-38 Bladder Point

On the Lateral film the bladder point is obtained on a line drawn anteroposteriorly through the center of the balloon at the posterior surface.

ICRU #38 (1985)

Spring 2013 | Asthema Cancer Society
ABS presented guidelines for using LDR and HDR in the management of patients with cervical cancer in early 2000 derived from an extensive literature review supplemented by its member’s clinical experience of over 100 years in GYN brachy.

The ABS recommendations are largely based on the classical Manchester system.

The original definition of the Manchester point A was useful for standardization, because it fell within the portion of the isodose distribution with little gradient in cephalo-caudal direction, running mostly parallel to the tandem.

Vs and VD were introduced to correlate dose with outcome and were defined as surface of vagina and 0.5 cm depth in vagina wall.

Vs dose should not exceed 150% of the point A dose.

- **Nominal Rectal point is equivalent to ICRU point and is** 0.5 cm posterior to vaginal wall (defined by radiopaque gauze used for packing) or diluted contrast in rectum. Attention should be paid to dose of sigmoid colon. Attention should also be given to radiographic visualization and dose to the sigmoid colon, because it may pass close to the tandem. Alternate localization tools, such as
As ABS recognized, the ICRU points for bladder in particular do not represent the hottest part of the bladder.

It is to be noted that the maximum bladder dose using three-dimensional dosimetry methods is usually higher than the maximum bladder dose obtained by conventional radiograph methods.
3D Bladder dose comparison

- 93 implants, ICRU bladder and rectal points compared 3D CT plans
- ICRU bladder point significantly lower (p<0.001) than 3D CT plan point $D_{av2}$

Dosimetric studies have found a good correlation between the dose to the ICRU rectal reference point and calculated maximal doses to the rectal mucosa. But it has also been shown that the maximal dose to the rectal mucosa may be found 1±2 cm more cranially or caudally than the ICRU reference point, depending on the geometry and loading of the source trains, and the dwell positions and times. Defining more points, computing dose distribution and deriving maximal doses, as proposed by several groups, seems to represent a promising approach.
CLINICAL INVESTIGATION

UNIQUE ROLE OF PROXIMAL RECTAL DOSE IN LATE RECTAL COMPLICATIONS: FOR PATIENTS WITH CERVICAL CANCER UNDERGOING HIGH-DOSE-RATE INTRACAVITARY BRACHYTHERAPY

Jason Chia-Heen Cheng, M.D., M.S.1,2,3 Lee-Cheng Peng, M.S.1,2 Yu-Huan Chen, M.D.4,5
David Y. C. Huang, Ph.D.1,2,6 Jian-Kuen Wu, M.S.1,2,7 and Jaeh-Jeong Jiang, M.D.1,2

Departments of 1Radiation Oncology and 2Medical Physics, Koos Foundation Sun Yat-Sen Cancer Center, Taipei, Taiwan; 3Division of Radiation Oncology, Department of Oncology, National Taiwan University Hospital and National Taiwan University College of Medicine, Taipei, Taiwan; 4Department of Radiation Oncology, Ming Chuan University Hospital, Taoyuan, Taiwan

- 89% percent of the patients had a maximal rectal dose at the proximal rectum instead of the ICRU rectal point.
- Late rectal complications was more prominent for the proximal rectal dose than for the ICRU rectal dose.
Lee et al investigated the Correlation of Point B and Lymph Node Dose in 3D-Planned HDR for Cervical Cancer Brachytherapy,

**Patients** with FIGO Stage IB-IIIB cervical cancer received 70 tandem HDR applications using CT-based treatment planning. The obturator, external and internal iliac lymph nodes (LN) were contoured. Point B dose was compared with LN dose-volume histogram (DVH) parameters by a paired t-test.

They concluded that the Point B is a poor surrogate for dose to specific nodal groups. They recommended that the dose specification at the 3D-defined nodal contours should be part of comprehensive planning of the total dose to the pelvic nodes, particularly when there is evidence of pathologic involvement of nodes.
Limitation of Point A

- No dose–volume relationship: It is a point and cannot be related to dose to the target.
This figure shows the variation of point A relative to Anatomy.

In this figure, Point A is inside the large cervix resulting in the underdosage of the cervix consequently the tumor.

Whereas the figure on the left represents a patient with a smaller cervix, Point A is outside of the cervix resulting in overdosage.
Point A relates to position of the sources. Sensitive to the ovoid position relative to tandem.
The failure of localization radiographs to show the surfaces of the colpostats made implementation of this process difficult, so in 1953, Tod and Meredith changed the procedure to begin at the most inferior point of the sources in the tandem (79). By the construction of the Manchester applicator, these two definitions essentially locate the same point. Use of this latter definition (or a common variant: beginning at the flange abutting the cervical os) with other applicators results in point A locations with a wider variation with respect to the colpostats (80, 81), often with point A falling in a high-gradient region of the isodose distribution. The result of this variation is that two patients with minor differences in the application can receive markedly different amounts of radiation. A location for consistent dose specification point A should fall sufficiently superior to the colpostats that the dose distribution runs parallel to the tandem.
Due to these limitations Image guided brachytherapy has been introduced.

To provide improvement in clinical outcome by allowing better tumor coverage and less treatment related complication.
a recent study by ABS surveyed the current practice and trend in GNY brachy.

Keep in mind that this survey went out in 2007 and may not reflect the current situation in 2012.

Based on this study, it does not look like the recommendation by ABS and GEC-ESTRO made the intended impact so far.

Vision tree Tech can you please show the survey results

![Table 1. Results of a survey of American Brachytherapy Society members on practice patterns in three-dimensional imaging during gynecologic brachytherapy, with and without international respondents](image)

<table>
<thead>
<tr>
<th>Imaging modality used for target dose specification</th>
<th>All members (n=133)</th>
<th>U.S. members only (n=119)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain film</td>
<td>43% (57)</td>
<td>43% (51)</td>
</tr>
<tr>
<td>CT</td>
<td>55% (73)</td>
<td>56% (67)</td>
</tr>
<tr>
<td>MRI</td>
<td>2% (3)</td>
<td>1% (1)</td>
</tr>
<tr>
<td>Prescription, target</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Point A</td>
<td>76% (101)</td>
<td>77% (92)</td>
</tr>
<tr>
<td>mg/h/Point A</td>
<td>3% (4)</td>
<td>3% (3)</td>
</tr>
<tr>
<td>Volumetric</td>
<td>14% (19)</td>
<td>13% (15)</td>
</tr>
<tr>
<td>Point A and volumetric</td>
<td>7% (9)</td>
<td>8% (9)</td>
</tr>
<tr>
<td>Prescription, OAR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ICRU</td>
<td>52% (69)</td>
<td>54% (64)</td>
</tr>
<tr>
<td>DVH</td>
<td>19% (25)</td>
<td>16% (19)</td>
</tr>
<tr>
<td>Both</td>
<td>29% (39)</td>
<td>30% (36)</td>
</tr>
</tbody>
</table>
So I would like spend little time to review 3D imaging for BT.

We have come to expect to prescribe treatments based on target volumes

Radiographic imaging fails to delineate soft tissues - either target or organs at risk.

Thus only with volume imaging we can plan and deliver accurately to the real target or control treatments with the control we are use to in external-beam radiotherapy

Doses have been prescribed to points A defined with respect to the applicator

– We do not know where the target is
– It could be that the very high dose near the applicator is what makes this treatment so effective.
As the goal is to treat in a manner similar to EBRT, we need a 3D imaging modality that allows accurate determination of size, shape, volume and extent of the target as well as the organs at risk.

In addition, it should allow accurate 3D dose computation.

It is important that image artifacts and distortion do not limit applicator and soft tissue visualization.

Logistically it should allow imaging and treating in the same position.
CT is the obvious candidate for volume-imaged based treatment planning for brachytherapy.

CT provides **3D relationship between the applicator and adjacent structures**

Fairly good soft tissue for contouring he organs at risk
MRI on the other hand provides

improved tissue contrast resolution

For the accurate determination of tumor size/volume/extension

It allows assessment of parametrium and vaginal

<table>
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<tr>
<th>MRI</th>
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<tbody>
<tr>
<td>improved tissue contrast resolution</td>
</tr>
<tr>
<td>• Accurate tumor size/volume/extension</td>
</tr>
<tr>
<td>• Assessment of parametrium and vaginal infiltration</td>
</tr>
<tr>
<td>• Image distortion</td>
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<tr>
<td>• MRI compatible applicator</td>
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</tbody>
</table>
In this figure an Axial computed tomography slice of pelvis immediately superior to ring applicator depicting parametrium in a patient with FIGO Stage IIB cervical cancer is shown. Both magnetic resonance imaging (solid line) and computed tomography (dotted line) contours are superimposed. Bilateral inconsistencies with regard to parametrial extension of high-risk clinical target volume can be seen. Computed tomography contours confirm significantly increased lateral extension of parametrial tissues contoured compared with MR imaging contour. Therefore, clinical examination and MRI before brachytherapy are critical to avoid unnecessarily contouring uninvolved parametrial tissue.

One may argue though it is safer to treat to CT volume b’c
Conclusion CT vs MRI

• MRI remains the standard for CTV definition.
• CT can significantly overestimate the tumor width
• Significant differences in the D90, D100, Vpd (volume treated to the prescription dose) for CTV compared with that using MRI.
• Both CT and MRI are adequate for OAR delineation
Recognizing the need for guidelines in IGBT

Differences in these guidelines caused some initial confusions
Consensus

• At a consensus conference in July 2005, it was agreed to adopt the GEC-ESTRO guidelines and to advocate 3D image–based planning for cervical cancer.
GOAL of the GEC ESTRO

- Establish a common language to describe the concepts and to define the terms and recommend guidelines which are to be used in IGBT applications
The delineation process is based on:

- clinical examination at diagnosis and at brachytherapy
- sectional images
  - preferably T2 weighted MRI taken at diagnosis and at BT with applicator in place.

The delineation process is based on:

clinical examination at diagnosis and at brachytherapy
on a set of sectional images
(preferably MRI T2 weighted) taken at diagnosis and at BT with applicator in place.
The first guidelines dealt with target definition.

The target concept is based on three CTVs according to tumour load and hence to the risk for recurrence: a high risk CTV with a macroscopic tumour load and an intermediate risk CTV representing significant microscopic disease. In addition, a low risk that is treated by surgery and/or by external beam radiotherapy and is not dealt with in detail.

The delineation process is based on clinical examination at diagnosis and at brachtherapy on a set of sectional images (preferably MRI T2 weighted) taken at diagnosis and at BT with applicator in place.
GEC ESTRO guidelines describe tumor definition in detail for different clinical situations,

The initial tumor extension at the time of diagnosis is key for the determination of HR-CTV and IR–CTV.
Cumulative dose volume histograms (DVH) are recommended for evaluation of the complex dose heterogeneity. DVH parameters for GTV, HR CTV and IR CTV are the minimum dose delivered to 90 and 100% of the respective volume: D90, D100. The volume, which is enclosed by 150 or 200% of the prescribed dose (V150, V200), is recommended for overall assessment of high dose volumes. V100 is recommended for quality assessment only within a given treatment schedule. For Organs at Risk (OAR) the minimum dose in the most irradiated tissue volume is recommended for reporting: 0.1, 1, and 2 cm³; optional 5 and 10 cm³. Underlying assumptions are: full dose of external beam therapy in the volume of interest, identical location during fractionated brachytherapy, contiguous volumes and contouring of all f O2 3 D l t d
To compare the effects of different dose rates and fraction sizes the linear-quadratic (LQ) model for incomplete mono-exponential sublethal damage repair is commonly applied and recommended for clinical practice for practical reasons. This model does not take into account the effects of dose heterogeneity of intracavitary brachytherapy as mentioned above. Reasonable estimates of $\alpha/\beta$ values for most of the tissues involved are available. The recommended model parameters proposed are $\alpha/\beta = 10$ Gy for the target volumes (squamous cell cancer) and $\alpha/\beta = 3$ Gy for the involved organs at risk such as bladder, rectum, sigmoid and small bowel. The effects of 3D image-based fractionated HDR brachytherapy can be well described applying the parameters of this model.
$\text{EQD}_2$

$\text{EQD}_2 = \frac{\text{BED}}{1 + \frac{2}{\alpha/\beta}}$

$\text{EQD}_2$ from external beam therapy and brachytherapy should be summed up assuming that the volumes and points of interest of brachytherapy receive the full external beam dose.
The parameter N indicates the number of fractions, the parameter d the dose per fraction and g the incomplete repair function, μ the repair rate constant with T1/2 the half time for sublethal damage repair.
GEC-ESTRO (II): Dose - EDQ2

D90
- HR-CTV: 85 Gy
- IR-CTV: 60 Gy

(Potter 2005)
3D Dose Distribution
To improve target coverage or to reduce doses to the OAR

Start from a standard loading pattern (applicator or tumour dependent)
LDR: Change the relative spatial or temporal distribution of the sources
HDR/PDR: Manipulating the source dwell positions and the relative dwell times

Some treatment planning systems provide (partly) automated optimisation tools. However, one should be careful with such techniques: dragging isodoses to encompass the target or to spare the OAR without evaluating the underlying relative weight of dwell times can be dangerous, as the resulting loading pattern and dose distribution may be significantly different from traditional approaches. High dose regions may remain undetected by DVH parameters.
Fig. A.3 Cervix cancer with distal left parametrial infiltration, minor remission after EBT + chemotherapy; intracavitary brachytherapy; HR CTV is contoured:

(a) Standard loading pattern: Coverage of HR CTV is insufficient; dose volume relations in organs at risk are appropriate.

(b) Optimised treatment plan - NOT RECOMMENDED: By dragging the isodose line to the left, HR CTV is appropriately covered on the left. This is achieved by completely changing the classical dose distribution (pear shape) (arrow), giving up the classical loading pattern for intracavitary brachytherapy, omitting all dwell positions on the right, without taking into consideration the dose volume relation in the rectum (R).

(c) Optimised treatment plan – RECOMMENDED: By stepwise adapting dwell time and location of intravaginal and intrauterine sources by modifying the classical loading pattern the best possible dose distribution is achieved by taking into account the dose volume relations in organs at risk. However, no complete coverage of HR CTV can be achieved in this case when both constraints are taken into consideration: additional interstitial brachytherapy or a boost by external beam therapy have to be considered. For full understanding in clinical practice, not only one coronal view is to be considered but the complete 3D volume of the true pelvis (transversal and sagittal), including dose volume parameters for GTV, CTV and organs at risk.
Table 1
Recommendations for recording and reporting 3D gynaecological brachytherapy

- Complete description of clinical situation including anatomy and pathology and imaging examination dimensions and volume of GTV at diagnosis and at time of brachytherapy
- Dimensions and volumes of HR CTV and IR CTV, respectively
- Complete description of 3D sectional imaging technique and contouring procedure
- Complete description of brachytherapy technique radionuclide: source type (wire, stepping source); source strength; applicator type; type of afterloading (manual or remote); description of additional interstitial needles if any
- Treatment prescription and treatment planning applicator reconstruction technique, standard loading pattern, dose specification method; optimisation method, if applied
- Prescribed dose
- Total Reference Air Kerma (TRAK)
- Dose at point A (right, left, mean)
- D100, D90 for GTV and HR CTV and IR CTV, respectively
- Dose to bladder and rectum for ICRU reference points D0.1cc, D1cc, D2cc for organs at risk (e.g. rectum, sigmoid, bladder) (vagina*)
- D0cc, D10cc for organs at risk if contouring of organ walls is performed
## PHYSICAL - BIOLOGICAL DOCUMENTATION OF GYNAECOLOGICAL HDR BT

### EXTERNAL BEAM THERAPY

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<th>Patient</th>
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### BRACHYTHERAPY

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<th>RTV, dly at 5%</th>
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### TUMOUR

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<th>V10</th>
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## Courtesy of Haie-Meder
Summary

• Point A based dosimetric systems are not ideal for GYN BT
• Volume based approach is likely to enhance cervical intracavitary brachytherapy.
• MRI -true target-based prescriptions
• CT may overestimate the target, however, this should not negate its value and its use in IGBT
• Until we gather enough data, we do not know the target and dose.
Post-test Question

Which one is not correct regarding the Point A?

A. Does not relate to the tumor volume
B. Different centers use different definitions and geometric locations for point A
C. ICRU #38 recommends reporting dose to the point A
D. Depends on the applicator and source position
From left to right: afterloading colpostats (2 cm diameter) and the plastic jackets used to increase the diameters to medium (2.5 cm) and large (3 cm); half cylinders (radius 0.8 cm) for narrow vaults (maximum diameter with the afterloading tandem in-between equals 3 cm) designed to have the vaginal sources perpendicular to the vaginal axis to minimize the dose to the bladder and rectum as compared with protruding sources with the axis parallel to the vaginal axis (the depth dose is not as effective as with one 3-cm colpostat); uterine afterloading tandems (the three most useful curvatures) having a metal flange with “keel” (to stabilize the tandem by means of proper packing around it) and without (to be used with vaginal cylinders); sample of vaginal cylinders of different diameters and lengths to be used for the implantation of vaginal brachytherapy. 
Ovoid shielding

- Mini – no inherent shielding
- Standard – shielding built in, but can vary significantly by manufacturer
- May provide up to 25% dose reduction

Figure 11.3. Transmission ratios (the fraction of the radiation transmitted through the tungsten shield) for a plane 1.2 cm from the top surface of the colposat with cap show a 10 to 25% reduction in the dose of radiation delivered to the tissues screened by the shield. (Reprinted with permission from Hass JS, Dean RO, Mansfield CM. Evaluation of a new Fletcher applicator using cesium-137. Int J Radiat Oncol Biol Phys 1980;6:1393. Copy-
Dosimetry in Endometrial Cancer

X: 0.5 cm depth at apex

250 cGy

800 cGy

750 cGy

Dose Optimization Points
Determining the necessary dose for tumour control and the tolerance levels of proximal normal tissues took several years of experience and inquiry. Clinical trials confirmed that tumour control probability was correlated with the radiation dose and cancer volume, and high doses were necessary to sterilise gross disease [5]. Over the next half a century, different systems evolved to more accurately prescribe the dose to the cervix, including the Stockholm and Paris mg/h systems, and the Manchester system of rads/h (cGy/h) with point dosimetry.

The standard dosimetric systems, including the Manchester, Paris, and Stockholm techniques, have a long and impressive record in the treatment and cure of cervical cancer. As originally described in 1938, the Manchester technique introduced a radium loading system designed to deliver a homogeneous dose distribution to a defined zone of tissue, known as the paracervical triangle. The point of limiting dose tolerance within the paracervical triangle was designated as point A, defined as 2 cm lateral to the central uterine canal and 2 cm from the mucous membrane of the lateral fornix in the axis of the uterus. Point B was designated as 5 cm from midline at the level of point A, and represented the dose delivered to the obturator lymph node, often the first echelon of metastatic spread. Point B was routinely recorded to calculate the cumulative dose to the pelvic sidewall delivered by brachytherapy and external-beam radiotherapy.
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ICRU PW Points

Definition of Pelvic Wall Points

Dose to distal parts of the parametrium and the obturator nodes.

Interaction of the superior aspect and the medial aspect of the scrotum.

Highest midline aspect point of the right and left scrotum.

ICRU #38 (1985)

ICRU reference volume

- Absorbed dose in BT is highly nonuniform
  - Max, min, mean dose are not relevant
- Steep dose gradient in BT
  - Reporting the dose or prescribing at specific point near the sources is less meaningful

ICRU proposed

“reference volume” enclosed by the “reference isodose surface” along with

“total reference air kerma (TRAK)”
Stocholm 1954 Paris 1964
I would like to start with a short overview of the dosimetric systems and their shortcomings.
Different dosimetric systems evolved to more accurately prescribe the dose in GYN BT.

Stockholm and Paris are both prescribed treatment as mg-h.
We are used to see evaluate plan using absorbed dose in tissue represented by isodose lines. As shown in this Stockholm system based treatment isodose lines are replaced by mg-h lines.

No absorbed dose concept
When used in adjuvant setting overall radiation cannot be define accurately.
To improve upon the manchester..

It was suggested that by defining and controlling of doses at various points in pelvis including:

- Pelvic nodes
- Bladder
- Rectum
- Vaginal surface

Would benefit patients by
Dose heterogeneity in brachytherapy is always present due to the rapid continuous dose fall-off near sources, originating mainly from the inverse square law effect and to a lesser degree from effective absorption in tissue. Additionally, dose heterogeneity in cervix cancer brachytherapy results from the presence of (partially) shielded applicators (towards the rectum and/or bladder). In most brachytherapy treatment planning systems (TPS), there is no correction for attenuation of applicator material nor is there any dose correction for tissue heterogeneity. These TPS limitations should be considered in clinical dosimetry [40].
Image-based treatment planning preferably uses MR or CT images with the applicator in place taking into account the directions of interest (uterus, cervix, rectum, bladder). In order to be CT/MR compatible, the classical shielding material, if used, should be removed. In that case, the dose to the organs at risk could increase. Non-metallic or titanium applicators cause limited distortion on CT or MR images. However, on MR images visualisation and localisation of the applicators might be difficult, especially if gadolinium contrast is used for packing.

When visualisation of catheter orientation is not clear on T2-weighted MR images, reconstruction has to be based on X-rays, additional CT scans or additional MRI sequences dedicated to visualize the applicator (e.g. T1). The resulting dose distribution has to be matched to MRI by using marking points visible in both imaging modalities (tip and centres of applicators, probes, bony structures, etc.).