MRI-brachytherapy in cervical carcinoma: a practical review for the radiologist

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Learning objectives

Exact staging of cervical malignant neoplasms is essential in the selection of the most favorable therapy. MR imaging plays a comprehensive role in primary tumor staging. It monitors response to treatment, detects recurrence and helps in the planning of radiotherapy. Patients with advanced disease (stages IB-IV) usually receive external-beam radiation therapy followed by intracavitary brachytherapy with concurrent chemotherapy. Brachytherapy based on cross-sectional imaging, especially MR imaging, improves local control and overall survival. MRI-based brachytherapy allows accurate positioning of the probe and the depiction of the tumor volume contour, which also permits individualized treatment planning. In order to obtain successful radiation treatment, the radiologist must provide the radiation oncologist with adequate knowledge regarding this technique and its possible complications.

Background

Imaging, especially MR imaging studies, has become an important feature in the clinical assessment of uterine cervical cancer. Because MR imaging is optimal for the evaluation of the main prognostic factors and planning of therapeutic strategy, it is now widely accepted as a comprehensive part in primary tumor staging, in the monitoring of response to treatment, and for detection of recurrence as well as planning of radiotherapy.

Patients with cervical cancer and stages IB2 (tumors larger than 4 cm) to stages IV commonly receive chemoradiation therapy and brachytherapy. Brachytherapy plays a critical role in the treatment of malignant cervical tumors, especially in patients with advanced disease where brachytherapy increases both local control and overall survival.

In cervical cancer, imaging-guided intracavitary brachytherapy is used for the delivery of high dose radiation to a focal tumoral area through an intrauterine applicator. Cross-sectional imaging with MR imaging or CT scan is necessary after brachytherapy probe insertion to assess the correct location of the applicator. CT studies are usually enough to delineate the organs at risk (normal tissues whose radiation sensitivity may lead to severe complications; in the case of cervical cancer, these are basically the bladder and the rectum). However, these studies are clearly suboptimal to define the residual tumor because of its lack of tissue resolution contrast in the pelvis.

The benefits of MR imaging for brachytherapy planning are that it provides accurate verification of the applicator position, identification of the residual tumor and detection of procedure-related complications. On the other hand, MRI-based brachytherapy provides an opportunity for conformal dose distributions to tumor volume and organs at risk as
well as the possibility for dose escalation leading to improved local control and reduced toxicity.

This procedure is feasible and efficient in routine clinical practice for patients with locally advanced cervical cancer. Therefore, the radiologist and radiation oncologist must be familiarized with this increasingly used therapy.

The purpose of this article is to highlight the knowledge that the radiologist must have regarding the MRI-guided brachytherapy technique and its possible complications.

**Imaging findings OR Procedure details**

**TECHNIQUE AND IMAGING PROTOCOL**

**MRI-brachytherapy probe insertion**

The brachytherapy applicator is inserted by direct vision into the vagina while the patient is under general anesthesia. The patient is then brought to the MR imaging room for study.

The most common applicator systems used are called tandem and colpostats, tandem and rings or tandem and cylinder. We normally used the Fletcher Suit Dèclos tandem and ovoid applicator (Fig 2). The tandem is a small caliber intracavitary stent that provides intrauterine radiation and the colpostat or ovoids deliver radiation directly to the cervix and the upper vagina (Fig 3). When the lower third of the vagina is involved, an interstitial implant or a cylinder applicator with tandem is recommended to cover all the tumoral area (5).

Surgical packing (several gauze sponges) is placed in the vagina to avoid vaginal injuries during the probe insertion and to hold the applicator in place.

The radiation source may be either a high dose-rate as iridium-192 or low dose-rate as cesium-137 source. Treatment results with low and high dose rates are equivalent in terms of local control and overall survival (6-9). High dose-rate brachytherapy has gained much attention as an alternative to traditional low dose-rate brachytherapy for cervical cancer because it causes minimal dislocation of the applicators and treatment can be performed on an outpatient basis (10,11). On the other hand, chemotherapy may be given with low dose-rate brachytherapy (it seem unnecessary to modify fraction and dose of the radiation treatment), but generally, it is not administered on the days of high dose-rate brachytherapy.

**Imaging protocol**
Those oncological radiology units that do not have access to MR imaging for planning radiotherapy generally use high resolution CT-based brachytherapy. The CT images are sufficient to evaluate for possible complications related to the position of the applicator and to define the organs at risk. However, they are clearly suboptimal to delineate the contour of the residual tumor after external radiation (12,13). (Fig 4,5).

The MRI-brachytherapy is routinely performed in our center. The patients are imaged on a 1.5 T (Signa GE, Milwaukee) with an 8-channel cardiac array coil. Images are obtained in sagittal, coronal and axial planes from the promontorium to the vulva with the applicator and the patient in the treatment position.

Our protocol includes a pre-procedure study using high resolution T2-weighted sequences (TE:min, TR:4800; FOV:28, thickness:3mm, matrix 256x256), that has great relevance because it can identify the residual tumor, which will appear as a hypointensity mass in T2-weighted sequences within the endocervical cavity or as a loss of the normal radiological appearance (hypointensity on T2-weighted images) of the cervical stroma. In this pre-implant MR-study we also performed a diffusion-weighted imaging sequence (TE:min, TR:6000; FOV:128; matrix:128x128; thickness:3mm; B:600), which identify the residual tumor as an area with restricted diffusion (Fig 6,7). In addition, this pre-implant study makes it possible to measure the cervicouterine angle and the length of the uterine cavity. The excessive angulation (ante or retroflexion uterine corpus) may lead to some difficulties for correct insertion of the applicator and finally to perforation of the myometrium. The marked uterine anteflexion is sometimes compensated by the bladder filling and a pull down maneuver of the anterior uterine cervix.

When the applicator is in place, a second post-implant acquisition is obtained when the patient is brought to the MR imaging room. The post-implant MR imaging protocol used only high resolution T2-weighted sequences with the same MR imaging parameters as the pre-procedure study. Although patients are under mild sedation, respiratory movements artifacts are common on T2-weighted sequences, due to patient anxiety. The brachytherapy probe causes paramagnetic artifacts on the diffusion images, so that the sequence is not useful in this MR imaging control study.

These post-implant images can ensure the correct position of the applicator, detect the residual volume tumor and detect possible complications of the procedure.

Teaching Point: "The MRI post-implant images ensure correct position of the applicator, in addition to assesment of residual volume tumor and possible complications of the procedure."

Correct position of the brachytherapy applicator

The MRI-compatible brachytherapy probe causes little artifact on spin echo sequences. It appears highly hypointense in all sequences.
The best plane to visualize the tip of the probe is the sagittal T2-weighted sequence, appearing at the bottom of the uterine cavity. When the applicator is in the correct position, the position of the tandem must be clearly seen at midline and midway between the colpostats that should be positioned in the fornices on the level of the tumor. Axial and coronal T2-weighted sequences are also very useful to identify the correct position of the tandem and ovoids (Fig 8,9). When the implant is in an incorrect position, the result is decreased rates of local control and survival (14).

On T2-weighted sequences, the several gauze sponges packed into the vagina are seen as low-signal-intensity material, which should not be misinterpreted as a mass (Fig 10).

Table 2 shows the signs to look for on MR post-implant studies.

Ovoids are an optimal solution when a large cervical tumor extends to the vagina, because the ovoid surface covers the whole vaginal fornix (Fig 11). On the other hand, when the cervical tumor reaches the distal third of the vagina, interstitial needles are the best therapeutic option to cover all the tumoral area (15).

**TP:** "An incorrect position of the brachytherapy probe reduces local control of the tumor and increase the toxicity to the adjacent tissues".

**Detection of the residual tumor**

In our center, the acquisition of a pre-procedure MR study is the rule to depict the residual tumor (seen as small hyperintense lesions on T2-weighted images and hyperintense lesions on spin echo diffusion weighted images) (Fig 12) and to achieve optimal delineation of the residual tumor contour.

This pre-implant MR studies facilitate the visualization of the residual tumor in the post-implant T2-weighted MR study and its relation with the brachytherapy applicator (Fig 13).

**TP:** "MRI-based brachytherapy is the imaging modality of choice to delineate the residual volume tumor, which must be included in the radiation map."

**THE RADIATION ONCOLOGIST’S VIEW**

Close collaboration between the radiologist and the radiation oncologist is essential to the planning of radiation treatment. Planning must be performed on the three spatial planes because the radiation target is a volume, defined by the dates (measures, shape, margins) from the diagnostic imaging modalities, (CT scan, MR imaging or PET studies). The change from 2D to 3D images has been published by GYN GEC-ESTRO group and the American Image-Guide Brachytherapy Working Group, who established the guidelines to define the clinical target volume and to plan brachytherapy treatment (16,17).

3D-image based MRI-brachytherapy provides proper information on target, organs at risk and dose volume histograms (18). The volumes obtained from MRI-guided brachytherapy
are gross target volume (GTV), clinical target volume (CTV) and organs at risk (OAR) (Fig 14). GTV corresponds to the gross palpable or visible/demonstrable extent and location of the malignant growth and CTV denotes the GTV (when present) as well as volumes with suspected (subclinical) tumors considered to need treatment. OARs are normal tissues whose radiation sensitivity may significantly influence treatment planning. In the case of cervical cancer, these are basically the bladder and the rectum.

In addition, the planning target volume (PTV) consists of the CTV and a margin to account for variations in size, shape, and position relative to the treatment beam. Therefore, the PTV is a geometrical concept used to ensure that the CTV receives the prescribed dose and it is defined in relation to a fixed coordinate system (19).

Accurate delineation of the tumor contour or GTV is possible with MRI-brachytherapy, identifying an intraluminal cervical mass and/or a loss of the hypointensity on T2-weighted sequence in cervical stroma. The CTV is individually tailored taking into consideration the gross target volume (GTV) in the initial pretreatment MRI-defined tumor volume. The isodose lines and CTV contours are superimposed for each MR axial image and also reconstructed in sagittal and coronal planes (Fig 15). The dose volume histograms are calculated for the target volume and dose volume for the OAR are usually calculated for the rectum, bladder and sigma (20,21).

TP "Specialists in diagnostic imaging are important collaborators in the contouring process".

**COMPLICATIONS OF RADIATION TREATMENT**

The goal for the radiation oncologist is to obtain "the highest probability of cure with the lowest risk of complications." Early and late sequelae of radiotherapy are progressively decreasing with modern therapy techniques and the introduction of pre-implant MR image acquisition into treatment planning. These have made reduction in PTV possible and consequently a reduction in the likelihood of complications.

"TP:" MRI-based dose conformation brachytherapy leads to reduction in the toxicity rate.

The earlier complication that may appear derived from the insertion of the brachytherapy probe is uterine perforation. Medium-long term complications of brachytherapy are vaginal or cervical stenosis, uterine atrophy, radiation enteritis and colitis, fistulae, proximal and distal recurrence and other complications as intraperitoneal free fluid, hydrosalpinx and stress fractures.

**EARLY COMPLICATION**

**Uterine perforation**

The pelvic tissues are more susceptible to damage after external beam radiation therapy. Manual insertion of the applicator can result in a small perforation of the uterine
myometrium, which is usually resolved with conservative treatment (22). The most common location of the perforation is the posterior uterine wall, close to the cervicouterine junction, although it can occur elsewhere. An excessive anterior angulation of the uterus increases the likelihood of the uterine perforation (Fig 16).

MR post-procedure study can identify if the applicator is incorrectly placed. A proper reposition of the intracavitary device before the initiation of the radiation therapy, does not affect local control and overall survival (Fig 17).

Pre-insertion pre-implant MR image acquisition study clearly benefits the process (measurement of the length of the uterine cavity, uterine position, election of the diameter of the applicator), decreasing overall complication rates. In centers where MR is not accessible for radiation therapy, an alternative method is US-guided insertion to assess the position of the tandem in the center of the uterine canal (23).

**LATE COMPLICATIONS**

**Focal stenosis and atrophy of gynecological organs**

Cervical stenosis is a common delayed sequelae of the brachytherapy treatment. On sagittal T2-weighted images, a hypointense narrow cervical channel with enlargement of the uterine cavity secondary to the retention of fluids can be visualized. Vaginal stenosis is also seen in serial MR imaging controls as a small canal with marked walls thickening (Fig 18).

The combination of the external radiation and brachytherapy can lead to uterine and ovarian atrophy. Follow up MR imaging studies show progressive loss of uterine and ovarian volume and a cervical effacement (Fig 19). The clinical importance of this complication is related to ovarian atrophy in premenopausal young women caused by ovarian failure due to radiation. An oophoropexy and ovarian transposition can be performed prior to pelvic radiation to preserve gonadal function.

**Radiation enteritis and colitis.**

Conformal dose brachytherapy has reduced the toxicity to the rectosigma. However, the majority of the patients with brachytherapy treatment have undergone previous external radiotherapy and a common finding is damage in the mucosa of the bowel loops, rectum, sigma or bladder. This is frequently a transient disorder, but may sometimes require hospitalization and surgical intervention (24). Acute toxicity is more common with concomitant chemotherapy.

On CT scan or MR imaging, radiation enteritis can be seen as abnormal distribution and distension of the bowel loops, thickening of the walls and heterogeneity of the pelvic fat (Fig 20). Rectosigmoiditis can be seen as marked wall thickening consistent with a symptomatic patient (abdominal pain, diarrhea and sometimes bleeding).
**Fistula**

Large tumor volumes sometimes require focal increases in radiation doses, increasing the radiation-induction toxic effects. Furthermore, the tissues around the tumor are often more friable and therefore are more susceptible to damage that favors fistulization. Bulky tumor necrosis secondary to the radiation therapy can also create a direct communication between any pelvic organ affected by the tumor.

Vaginal fistula (vesicovaginal, ureterovaginal or rectovaginal fistula) is the most common type of fistula in cervical malignancies, especially in patient with brachytherapy (25). In the irradiated tissue, the fistulas are complex, with large or multiple tracts. Less frequent types of fistulae are enterovesical or enterocutaneous fistulae.

Imaging of the fistulous tracts can be depicted with CT scan or MR imaging. MR imaging can clearly identify the fistulous tract on T2-weighted images, where the fistula is typically seen as a high-signal intensity, fluid-filled communication. Fat saturated and diffusion sequences may help identify the small tracts (Fig 21).

By determining presence of residual tumor, MR imaging, is crucial to differentiate whether the fistula is secondary to treatment effects or secondary to recurrence. This fact determines what type of surgery is appropriate: interposition graft, diversion or exenteration techniques. Exenteration is the surgery of choice in local recurrence without affection of the pelvic side wall (26) (Fig 22).

When a communication with the urinary tract is suspected, intravenous contrast uro-CT scan in the excretory phase may be an excellent imaging modality. Three-dimensional CT reconstructions of complex vesicovaginal fistulas provide the detailed anatomic views that the surgeon needs for preoperative planning (Fig 23).

**Recurrence**

Relapse cervical carcinoma after intracavitary brachytherapy can be focal or diffuse. Focal recurrence is seen on T2-weighted images as hyperintense nodular ill-defined endoluminal mass and/or hyperintense lesions blurring the cervical stroma similar to the original tumor. Other radiological findings suggesting focal recurrence are marked restricted diffusion on spin echo diffusion weighted images and early enhancement in dynamic postgadolinium sequences (Fig 24). The differential diagnosis is nodular post-radiation treatment fibrosis (Fig 25), appearing as hypointense or hyperintense nodular lesions, with absent restricted diffusion and progressive gadolinium enhancement, although the definitive radiological diagnosis is not always possible.

A distal focal uterine recurrence sometimes occurs in the limits of the brachytherapy area. A hyperintensity mass in the uterine cavity can be identified on sagittal or axial T2-weighted images with different degrees of myometrial invasion (Fig 26).
Diffuse recurrence of cervical carcinoma can appear as multiple pelvic peritoneal implants, enlarged retroperitoneal enlarged lymph nodes or distant metastases.

**Other complications**

Coexistent pathological pelvic minor complications (27) as intraperitoneal free fluid (Fig 27) as small hydrosalpinx (Fig 28) may often develop between the interval of the external beam radiotherapy and brachytherapy.

Sacral insufficiency fractures are another possible complication derived from the external radiation therapy that frequently appear at the time of the brachytherapy treatment. Hyperintensity areas on fat-suppressed T2-weighted images secondary to edema are clearly visualized in patients with back pain (Fig 29).

**Images for this section:**

![Fig. 1](image1.png)

**Fig. 1:** Fig. 1. Cervical carcinoma FIGO stages IB, IIA and IIB. Axial T2-weighted images. (a) Normal "doughnut" appearance of the uterine cervix with hypointensity of the cervical stroma and the endocervical canal in the center. (b) Cervical carcinoma stage IB: an intermediate-high signal intensity mass causes interruption of the low signal intensity
stromal circumference without parametrial invasion (white arrow). (c). Cervical carcinoma stage IIA: cervical mass extending to the upper vagina with stromal invasion. (d). Cervical carcinoma stage IIB: Parametrial extension of cervical cancer. The tumor has completely replaced the posterior cervical stroma and extends into the parametrial fat (black arrow).

**Fig. 2:** Fig. 2. MRI-compatible brachytherapy probe. (a) Photograph shows a Fletcher-Suit-Dèclos tandem and ovoid applicator. (b) Frontal and lateral views of 3D MDCT reconstructions of the applicator.
**Fig. 3:** Brachytherapy applicator in place. (a). Schematic diagram showing the applicator position within the uterus (U) and its relations with the bladder (B), rectus (R) and vagina (V). (b) Sagittal T2-weighted image shows the tip of the applicator (white arrow) in the uterine cavity, the ovoids (white dot) in the cervix and a urinary catheter in the bladder (B).
Fig. 4: Fig. 4. CT-based brachytherapy. (a) Sagittal maximum intensity projection (MIP) view of the applicator and (b) 3D volume rendered (VR) multidetector (MDCT) image. CT scan can identify both the metallic structure and the dispositive location. The residual tumor cannot be visualized. Tandem (white arrow); ovoids (black dots).
**Fig. 5:** Fig 5 CT-based brachytherapy. (a) Coronal and (b) axial MIP images. Tandem (white arrow) and ovoids (black dots) are clearly shown, assessing the correct position of the probe.
Fig. 6: Cervical carcinoma stage IIB. Pre-treatment MRI study. (a,b,c) Axial T2, axial diffusion and sagittal T2-weighted images, respectively show a high-signal intensity cervical mass extending to the left parametrium.
**Fig. 7:** Fig 7. Cervical carcinoma stage IIB. Post external beam radiation treatment and pre-brachytherapy MR imaging study. (a,b,c) The MR images reveal a minimum residual tumor in the endocervical canal (dashed white arrow), appearing as an intermediate-signal intensity mass on T2-weighted images, with a minimal hyperintensity on diffusion-weighted images. The cervical stromal has returned to its normal low-signal intensity.
**Fig. 8:** Fig 8. Correct position of the brachytherapy probe. (a,b) Sagittal T2-weighted image shows the tip of the tandem (white arrow) at the bottom of the uterine cavity. Ovoids (white dots) are placed in the vaginal fornices along the cervix. U: uterus; B: bladder; R: rectum; V: vagina.
Fig. 9: Correct position of the brachytherapy probe. (a) Coronal and (b) axial T2-weighted images show the tandem (white arrow) located in midline and midway between the colpostats. U: uterus; B: bladder; R: rectum; V: vagina.
**Fig. 10:** Vaginal packing. (a,b) Coronal T2-weighted images identify the low signal intensity of the vaginal packing (double open white arrow) in the vaginal cavity. Dashed white arrow: tandem; white dots: ovoids.
**Fig. 11:** Cervical carcinoma invading the upper vagina. (a) Sagittal T2-weighted image obtained at the time of diagnosis, with US-sterile gel distending the vaginal cavity. Large intermediate-signal intensity mass in the posterior vaginal fornix (dashed white arrow). (b) MR-imaging study with the brachytherapy applicator in place (white arrow). Ovoids (dot) are an optimal solution, because their surface cover all the upper vagina. (c) Successful post-brachytherapy treatment. Sagittal T2-weighted image with absence of residual tumor and collapse of the vaginal fornix.
Fig. 12: Fig 12 Residual tumoral volume. (a) Pre-insertion MR-study. Radiological findings of abnormal signal intensity of the right cervical stroma on axial T2-weighted image and (b) high-signal intensity of the right cervical stroma on diffusion-weighted image are consistent with persistent tumor (dashed white arrow) after external radiation treatment. (c) Post-insertion MR-study. Axial T2-weighted image with the applicator in place (white arrow), allows visualization of the residual mass.
Fig. 13: Residual tumoral volume. (a,b) Pre-insertion MR-study clearly reveals the residual stromal tumor (dashed white arrows) as intermediate-signal intensity (c) MR-imaging based brachytherapy. Sagittal T2-weighted image with the applicator (white arrow) in a central position related to the tumor, which is in direct contact with the colpostats (white dot). (d) Axial T2-weighted image helps in the correct identification of the tumor volume.
Fig. 14: Fig 14 Target volume radiation (a,b) Sagittal and axial T2-weighted images of the diagnosis MR study of a bulky endocervical tumor in stage IB2. (c,d) Sagittal and axial T2 weighted images with brachytherapy applicator in place. Great reduction of the tumoral volume after external beam radiation treatment. GTV (dashed white circle): determines the residual visible tumoral volume; CTV (dashed orange circle): denotes the GTV plus suspected subclinical tumor volumes, usually coinciding with the volume of the tumor at the initial diagnosis; PTV (dashed red circle): CTV and a margin to account for variations in size, shape, and position relative to the treatment beam.
Fig. 15: Fig 15 Radiation map. The isodose lines and CTV contours are superimposed for each MR axial image and also reconstructed in sagittal and coronal planes. The dose volume histograms are calculated for the target volume and doses for organs at risk (OAR), usually rectum, bladder and sigma.
Fig. 16: Fig 16. Complication: uterine perforation. (a) Sagittal T2-weighted image identifies the penetration of the tandem (white arrow) in the myometrium. (b) Sagittal T2-weighted image reveals posterior uterine perforation with the tandem close to the bowel loops (dashed white arrow). (c,d) Anterior uterine perforation visible on sagittal and axial T2-weighted images, without affection of the posterior bladder wall.
Fig. 17: Relocation of the brachytherapy applicator. Sagittal T2-weighted images.
(a) Pre-implant MR study without evidence of residual tumor. (b) The tandem (open arrow) is anteriorly located, perforating the ventral myometrium due to the marked retroflexed uterus. (c) A relocation was performed, displacing inferiorly the tandem. White dots: colpostats
Fig. 18: Complication: focal stenosis. Sagittal T2-weighted images. (a) Cervical stenosis. Wall thickening and low-signal intensity of the cervix (white arrow) secondary to radiation treatment, without visualization of the endocervical canal. Uterine cavity distension with retention of fluids (open white arrow) (b) Vaginal stenosis. Small distal vagina with closed of the upper two thirds of the vaginal cavity (dashed arrow)
Fig. 19: Complication: atrophy. (a,b) Uterine atrophy. Progressive small uterus is seen on serial sagittal T2-weighted images with effacement of the cervix.
**Fig. 20:** Complication: enteritis. (a) Axial enhanced-CT image (b) Axial T2-weighted image. Abnormal distribution and distension of the bowel loops, thickening and post-contrast enhancement of the bowel walls (arrows) and heterogeneity of the pelvic fat.
Fig. 21: Complication: vesicovaginal fistula. (a) Sagittal T2-weighted image evidence a bulky cervical mass invading the upper vagina (large white arrow) and the bladder wall (white arrows). (b) Post-brachytherapy treatment. Partial response with residual cervical tumor extending to the bladder and the anterior vaginal wall. Sagittal T2-weighted image depict a small high-signal intensity tract (dashed white arrow) connecting the vagina and the posterior wall of the bladder, suggesting a fistula. (c, d) Post-gadolinium-enhanced images in sagittal and axial planes show a huge vesicovaginal fistula secondary to tumoral necrosis.
Fig. 22: Exenteration in patient with local pelvic relapse. (a) Sagittal (b) axial and (c) coronal T2-weighted images. Anterior exenteration (hysterectomy, anexectomy, bladder and vaginal resection) was performed with a vertical rectus abdominis musculocutaneous flap (VRAM) (white arrows) vaginal reconstruction. The rectus abdominis is pulled back and inferiorly to the minor pelvis (curved black arrow)
Fig. 23: Vesicovaginal fistula. Patient with complete remission after chemoradiation treatment and hysterectomy. Six months later, persistent vaginal discharge led to the clinical suspicion of a vesicovaginal fistula. (a) Three dimensional-Maximum intensity projection (3D-MIP) reconstructions (b) Volume Rendering CT images and (c) sagittal MIP reconstruction in a excretory phase. A large vesicovaginal fistulae is shown (white arrows) with a large tract between the bladder and the upper vagina. The iodated intravenous contrast filled the vaginal cavity (dashed white arrow). The distal third of the right ureter is not visualized secondary to peristalsis.
**Fig. 24**: Focal cervical recurrence. Vaginal distension with sterile gel. (a,b) Focal ill-defined high-signal intensity mass (white arrow) on sagittal and axial T2-weighted images. (c) High-signal intensity on diffusion-weighted image and (d) increase nodular uptake of gadolinium contrast on enhanced sequence, suggesting cervical relapse.
Fig. 25: Fig 25. Post-brachytherapy treatment fibrosis. Vaginal distension with sterile gel. (a,b) Cervical effacement (dashed white arrow) with diffuse low-signal intensity on sagittal and axial T2-weighted images. (c) Absence of abnormal signal intensity on diffusion-weighted image. (d) Gadolinium-enhanced image do not show any uptake of contrast in cervical tissue
**Fig. 26:** Distal uterine recurrence in a patient with a previous complete regression of a cervical carcinoma after chemoradiation treatment. (a,b) Sagittal and axial T2-weighted images reveal an intermediate-signal intensity mass in the uterine fundus (white arrows), invading the myometrium. Retention fluids are seen in the endometrial cavity (asterisk). (c) The compact mass is highly hyperintense on diffusion-weighted image and (d) enhances partially (white arrow) in post-gadolinium images.
**Fig. 27:** Fig 27. Sagittal T2-weighted image. Small amount of fluid in Douglas sac (asterisk) that may cause pelvic pain.
Fig. 28: Hydrosalpinx. (a,b) Small left hydrosalpinx (black arrow) is seen on coronal T2-weighted images as a high-signal intensity fluid filled tubular structure that arises from the upper lateral margin of the uterus
**Fig. 29:** Sacral insufficiency fractures. (a) Axial T1-weighted image shows symmetrical low-signal intensity in both sacral wings. (b) Axial T2-weighted image evidence bilateral abnormal high-signal intensity secondary to the medullary edema. Dashed arrows: lines fractures.
Conclusion

Brachytherapy increases both local control and overall survival, especially in patients with advanced disease, indicating the critical role of brachytherapy in the treatment of malignant cervical tumors.

Dose conformation with MRI-based brachytherapy improves local control and reduces the rate of complications. In routine clinical practice, this procedure is feasible and efficient for patients with locally advanced cervical cancer.

The radiologist must be familiarized with this increasingly-used therapy and its possible complications.

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Personal Information