The prostate treated for prostatic carcinoma: magnetic resonance (MR) recurrence patterns

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Learning objectives

To illustrate the most frequent MR imaging appearance of the prostate treated for prostate cancer, after surgical and ablative treatments.

To review the most frequent recurrence patterns after prostate surgical and ablative treatments.

To evaluate the most effective MR imaging examination techniques.
Background

Surgical and ablative treatments for prostate carcinoma are: (a) Radical prostatectomy; (b) Radiotherapy; (c) Brachytherapy; (d) Cryoablation; (e) High Focused UltraSound (HIFU) ablation (1).

MR is an effective imaging technique in the follow-up of treated prostate (1).

We reviewed 149 cases of MR examinations of patients with prostate cancer, treated with radical prostatectomy, radiotherapy, brachytherapy, cryoablation and HIFU ablation, to illustrate MR imaging patterns of the treated prostate and most frequent recurrence patterns.
Imaging findings OR Procedure details

MATERIALS AND METHODS

149 patients treated with radical prostatectomy, radiotherapy, brachytherapy, cryoablation and HIFU ablation performed MR follow-up between July 2005 and February 2010.

All MR examinations were performed with a 1.5T MR system (Philips Gyroscan Intera Power), using a dedicated endorectal coil. Pts treated with cryotherapy were examined using the body phased-array coil.

All the patients underwent MR conventional multiplanar Turbo Spin-Echo (TSE) T2w sequences, followed from dynamic axial contrast enhanced (ce) Gradient-Echo (GRE) T1w sequence. In some patients we also performed MR spectroscopic acquisitions.

IMAGING FINDINGS

A) RADICAL PROSTATECTOMY

Background

Radical prostatectomy with a retropubic or perineal approach is the most frequently used treatment for prostate carcinoma confined to the gland. Prostate and seminal vesicles are removed and is created an anastomosis between the bladder and the membranous urethra. One or both of the neurovascular bundles surrounding the prostate are spared to preserve potency in patients with clinically localized disease. Pelvic lymphadenectomy may precede both retropubic and perineal prostatectomy in patients with a prostate-specific antigen (PSA) level of more than 10 ng/mL and a Gleason score of at least 7 (1,2).

Postoperative anatomy

The normal vesicourethral anastomosis showed a smooth, conelike morphology, without plication abnormalities (Fig. 1). A non-enhancing low signal nodule was frequently seen at the anastomosis and usually represents fibrosis. Retropubic fat pad was reduced or absent following a retropubic approach. Anterior rectal-wall scarring was present following a transperineal approach (1,2,3).

Patterns of recurrence

After Radical Prostatectomy, recurrent prostate carcinoma appeared as an enhancing mass in the surgical site. Local recurrences were located around the area of the urethrovessical anastomosis, at the bladder neck or in the retrovesical space. On
conventional T2w MR images local recurrences resulted slightly hyperintense compared to the perianastomotic tissue. On dynamic ce-GRE T1w MR images local recurrences showed focal early enhancement compared to the perianastomotic tissue (4,5,6) (Fig. 2, Fig. 3, Fig. 4).

B) RADIOTHERAPY

Background

17% of newly diagnosed patients undergo external-beam radiation therapy as definitive treatment for clinically localized disease (7).

Post treatment anatomy

Morphologic MR evaluation showed (a) parenchimal fibrosis and atrophy, (b) reduction in size of the gland, (c) postirradiation zonal indistinctness on T2w images due to a diffuse reduction in secretion volume and T2w signal intensity. Dynamic ce MR evaluation showed a reduction of the vascularization of the gland. MR spectroscopy showed metabolic alterations, with decrease of metabolites, in particular of citrate (1,7,8) (Fig. 5).

Patterns of recurrence

After radiation therapy, recurrent prostate carcinoma appeared as focal nodular region of reduced signal intensity at morphologic T2w MR images. On dynamic ce MR images local recurrences showed greater enhancement compared to the perilesional prostatic tissue. The pattern of the Time/Intensity curves of the lesions resulted similar to the patterns of the pathologic curves before the treatment. MR spectroscopic evaluation showed increased (Cho + Cr)/Cit ratios and/or the presence of Cho voxels in regions with metabolic atrophy (6,7) (Fig. 6, Fig. 7).

C) BRACHYTHERAPY

Background

Permanent low dose-rate brachytherapy is an alternative therapeutic option to radical prostatectomy as well as to conformal radiotherapy in patients with clinically localized carcinoma (9) (Fig. 8).

Post treatment anatomy

Morphologic MR evaluation showed (a) reduction in size of the gland, (b) diffuse reduction of signal intensity on T2w images due to parenchimal fibrosis and atrophy. Dynamic ce MR evaluation showed a reduction of the vascularization of the gland. Radiation therapy seeds were seen on T1w images as small foci of focal signal intensity void inside the prostate gland parenchima. On T2w images prostate anatomy was better visualised due
to the high contrast naturally available between the gland and the surrounding tissues (9) (Fig. 9).

**Post-implant dosimetry**

MR imaging is also used for post-implant dosimetry. The post-plan dosimetries were based on GRE T1w (to locate the radioactive sources) and TSE T2w (to visualise the prostate) imaging. Post-implant dosimetry was performed on fused transverse T1w and T2w MR images, using dedicated image fusion softwares (10) (Fig. 10).

**Patterns of recurrence**

Recurrent prostate carcinoma after brachytherapy appeared as focal nodular region of intermediate signal intensity on T2w MR images, with greater enhancement compared to the perilesional prostatic tissue on dynamic ce MR images (9) (Fig. 11, Fig. 12).

**D) CRYOTHERAPY**

**Background**

Cryosurgery is the term used to describe tissue destruction using extreme cold temperature (Fig. 13). The histologic sequelae of this process are inflammatory reaction, coagulative necrosis and finally fibrosis and scarring.

Cryosurgical ablation is a safe, well tolerated and minimally invasive alternative therapy for localized prostatic carcinoma.

As it is not possible to document histopathologically the complete tissue necrosis after cryoablation and PSA level results variable during the follow-up, a radiological follow-up can be helpful. MR can be an effective imaging technique in the follow-up of prostate tumors treated with cryosurgical ablation, in particular in the early evaluation of the efficacy of the treatment (immediate feedback about size and geometry of the cryoinsult) and in the evaluation of patients with clinical or laboratory suspect of recurrence (11,12).

**Post treatment anatomy**

Cryolesions tipically appeared to be isointense on T1w images and hypo- or hyperintense on T2w images due to the coagulative or colliquative necrosis induced by cryotherapy. All cryolesions showed an increase in size 24 hours after treatment, due to postcryosurgery prostate edema, and a progressive decrease in size (more than 80% at 36 months) due to fibrotic evolution of cryolesions. Treated prostate showed no significant vascularization of the peripheral zone, with periurethral zone sparing, on ce-MR images, due to vasocostriction and thrombosis of distal arterioles and venules induced by cryotherapy (11,12) (Fig. 14).
The most significant MR patterns in the follow up of prostatic carcinoma treated with cryosurgical ablation were the decrease in size of the gland with the passing of time and the complete ischemia of the prostate, with periurethral zone sparing.

The most effective MR techniques for lesions size and enhancement evaluation were TSE T2w and subtracted ce-GRE-FS T1w sequences (12).

**Patterns of recurrence**

On MR images local recurrences after prostate cryoablation showed focal nodular areas with intermediate signal intensity on T2w images and contrast enhancement on ce GRE T1w images (Fig. 15).

E) HIFU ABLATION

**Background**

HIFU ablation is an alternative treatment for localized prostate carcinoma, that has the potential to treat the tumor minimizing the sexual and urinary morbidity that accompany radical therapies.

The treatment is performed using a endorectal probe cabable of provide real-time diagnostic imaging or high energy for therapeutic ablation. The treatment induces a coagulative necrosis of the gland (13) (Fig. 16).

MR can be an effective imaging technique in the follow-up of prostate tumors treated with HIFU ablation, in particular in the early evaluation of the efficacy of the treatment and in the evaluation of patients with clinical or laboratory suspect of recurrence (13).

**Post treatment anatomy**

After the treatment, the prostate showed predominantly low signal inten- sity on both T1w and T2w MR images, with poor definition to the capsule and with heterogeneous signal intensity of the surrounding fat. Treated glands showed an increase in size 24 hours after treatment and a progressive decrease in size (more than 45%), due to fibrotic evolution. On ce-dynamic MR images the treated gland showed nonenhancing, low signal intensity within the prostate, extended outside the gland and involved the periprostatic fat and the levator ani muscle (Fig. 17).

The most significant MR patterns in the follow up of prostatic carcinoma treated with HIFU ablation were the decrease in size of the gland with the passing of time and the complete ischemia of the prostate, with periurethral zone sparing. The most effective MR techniques for lesions size and enhancement evaluation were TSE T2w and subtracted ce-GRE-FS T1w sequences (13).

**Patterns of recurrence**
On MR images local recurrences after prostate HIFU ablation showed focal nodular areas with intermediate signal on T2w images and contrast enhancement on ce GRE T1w images (Fig. 18).
**Fig. 1:** Fig. 1 RADICAL PROSTATECTOMY NORMAL ANATOMY Normal vesicourethral anastomosis shows cone-like morphology on MR images (arrows), with low signal intensity on T2w images (A,B,C) and non-enhancing pattern on post contrast GRE T1w images due to fibrosis (D).

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Fig. 2: FIG. 2 RADICAL PROSTATECTOMY RECURRENCE 4 YEARS AFTER TREATMENT Transverse (A) and sagittal (B) TSE T2w MR images show solid tissue with signal intensity slightly higher than that of the adjacent pelvic muscles in the posterior wall of vesico-urethral anastomosis (arrows), isointense on GRE T1w image (C). After injection of contrast material, ce GRE T1w image showed fast enhancement of the lesion (D, arrow), better evaluated on subtracted ce GRE T1w image (E, arrow). The time/intensity curve from the lesion shows more intense enhancement (arrow) compared to the time/intensity curve of the perianastomotic tissue (F)

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Fig. 3: FIG. 3 RADICAL PROSTATECTOMY RECURRENCE 6 YEARS AFTER TREATMENT Transverse (A) and sagittal (B) TSE T2w MR images show high signal intensity tissue in the left retrovesical region (arrows), isointense on GRE T1w image (C). After injection of contrast material, ce GRE T1w image shows fast enhancement of the lesion (D, arrow). Better evaluation of the lesion on subtracted ce GRE T1w image (E, arrow). The time/intensity curve from the lesion shows more intense enhancement compared to the time/intensity curve of the normal right retrovesical region (F).

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**Fig. 4:** FIG. 4 RADICAL PROSTATECTOMY RECURRENCE 3 YEARS AFTER TREATMENT Transverse (A) and sagittal (B) TSE T2w and unenhanced GRE T1w (C) MR images show no lesion in the perianastomotic zone. Focal early enhancement in the left perianastomotic tissue on conventional (C) and subtracted (E) dynamic ce GRE T1w image (arrow). The time/intensity curve from the lesion shows more intense enhancement compared to the time/intensity curve of the normal right perianastomotic tissue (F).

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Fig. 5: Fig. 5 RADIOTHERAPY NORMAL ANATOMY Transverse (A) and sagittal (B) TSE T2w MR images show reduction in size and signal intensity of the gland due to parenchimal fibrosis and atrophy, with diffuse reduction in secretion volume. On MR spectroscopic images (C,D) the gland shows decrease of metabolite levels, in particular of citrate, due to parenchimal atrophy

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Fig. 6: FIG. 6 RADIOTHERAPY RECURRENCE 4 YEARS AFTER TREATMENT
Transverse (A) TSE T2w MR image shows a hypointense lesion of the right anterolateral zone of the prostate (arrow). After injection of contrast material, dynamic ce GRE T1w image shows fast enhancement of the lesion (B). MR spectroscopic evaluation (C,D) shows increased (Cho + Cr)/Cit ratio (2.06).

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**Fig. 7: FIG. 7 RADIOTHERAPY RECURRENCE 6 YEARS AFTER TREATMENT**

Transverse (A) TSE T2w MR image shows reduction in size of the prostate, with small area of intermediate signal intensity in the right peripheral zone (arrow). Subtracted ce-dynamic MR images (B,C) show marked enhancement of the lesion (red circles). MR spectroscopic evaluation (D) shows the presence of Cho voxels.

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Fig. 8: FIG. 8 BRACHITHERAPY TREATMENT TECHNIQUE Iodine-125 seeds (A). Needles containing radioactive sources (B) are placed throughout the prostate under transversal ultrasound control, with the aid of a needle-spacing template (C)

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**Fig. 9:** FIG. 9 BRACHITHERAPY POST IMPLANT NORMAL ANATOMY Transverse GRE T1w (A), TSE T2w (B) and fused transverse GRE T1w and TSE T2w (C) MR images. Diffuse reduction of signal intensity on T2w image (B) due to parenchimal fibrosis and atrophy. Radiation therapy seeds are seen on GRE T1w image (as small focal signal intensity voids) while the anatomy is well visualised on TSE T2w image. Fused MR images are obtained for 3D reconstruction of the performed implant.

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**Fig. 10:** FIG. 10 BRACHITHERAPY MR POST IMPLANT DOSIMETRY Post-implant dosimetry based on fused transverse GRE T1w and TSE T2w MR images. The yellow line represents the isodose line of the reference dose.

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Fig. 11: BRACHITHERAPY RECURRENCE 4 YEARS AFTER TREATMENT

Transverse (A) TSE T2w MR image shows reduction in size of the prostate, with small area of intermediate signal intensity in the left peripheral zone (arrow). After injection of contrast material, subtracted ce GRE T1w image shows fast enhancement of the lesion (B, arrow). Better evaluation of the lesion on fused TSE T2w and ce GRE T1w image (C, arrow).

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Fig. 12: FIG. 12 BRACHITHERAPY RECURRENCE 3 YEARS AFTER TREATMENT
Transverse (A) and coronal (B) TSE T2w MR images show reduction in size of the prostate, with small foci of focal signal intensity void inside the gland due to the presence of radiation therapy seeds. Small area of intermediate signal intensity in the right peripheral zone (arrow), showing fast enhancement on conventional (C) and subtracted (D) dynamic ce GRE T1w images (arrows).

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**Fig. 13:** FIG. 13 CRYOTHERAPY TREATMENT TECHNIQUE 17G cryoneedle and the iceball (A). Scheme of cryoprobes placement into the prostate gland (B). 17G cryoneedles inserted through the perineum (C). Ultrasonograph underic evaluation of cryoneedle position, to outline the shape of the prostate (D). Development of the iceball under ultrasound control (E,F,G)

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**Fig. 14:** FIG. 14 CRYOTHERAPY NORMAL ANATOMY 24 hrs after treatment, cryolesion was more than 10 mm larger than the original gland; progressive decrease in size at 12 and 36 months after surgery. Subtracted ce-T1w MR images showed ischemia of the peripheral gland and enhancement of the central portion of the prostate, due to the sparing of the periurethral zone.

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**Fig. 15:** FIG. 15 CRYOTHERAPY RECURRENCE 3 YEARS AFTER TREATMENT
Increase in size and vascularization of the periurethral spared zone (red arrows) on MR images at 36 months from treatment, in patient with increase of PSA level. Biopsy findings suggested a local recurrence.

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**Fig. 16:** FIG. 16 HIFU ABLATION TREATMENT TECHNIQUE Scheme of position of the HIFU endorectal probe, capable of provide real-time diagnostic imaging or high energy for therapeutic ablation.

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**Fig. 17:** FIG. 17 HIFU ABLATION NORMAL ANATOMY After the treatment, the prostate shows predominantly low signal intensity on both T2w (A) and T1w (B) MR images. Subtracted ce-dynamic MR image (C) shows lack of enhancement of the treated gland.

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**Fig. 18:** FIG. 18 HIFU ABLATION RECURRENCE 2 YEARS AFTER TREATMENT
Transverse (A) and sagittal (B) TSE T2w MR images show low signal intensity of the peripheral gland, with an area of intermediate signal intensity in central zone (arrow). After injection of contrast material, conventional (C) and subtracted (D) ce GRE T1w images show fast enhancement of the lesion (arrows)

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Conclusion

DISCUSSION

The most effective examination techniques in the MR evaluation of pts treated with surgical or ablative therapies for prostate carcinoma were multiplanar TSE T2w and dynamic GRE T1w sequences. A useful additional technique was MR spectroscopy.

The most important parameter in the MR imaging evaluation of patients treated with radical prostatectomy for prostate carcinomas was the absence of enhancing nodules, at the excision site and at the perianastomotic space.

The most important parameters in the evaluation of conservative treatments were the lack of increase in size and the hypovascularization of the treated areas. The most important parameters in the evaluation of recurrences were the presence of nodular patterns of enhancement on dynamic MR study in the treated areas, associated to the increase of (Cho + Cr)/Cit ratio on spectroscopic images evaluation.

CONCLUSION

MR is an effective imaging technique in the follow-up of treated prostate. The most effective examination techniques were multiplanar TSE T2w and dynamic GRE T1w sequences. A useful additional technique in the evaluation of the prostate after radiotherapic and ablative treatments was MR spectroscopy. The most important parameter in the evaluation of recurrences was the presence of nodular patterns of enhancement on dynamic MR study in the treated areas.
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References


2) Allen SD, Thompson A, Sohaib SA "The normal post-surgical anatomy of the male pelvis following radical prostatectomy as assessed by magnetic resonance imaging" Eur Radiol (2008) 18: 1281-1291


5) Manzone TA, Malkowicz SB, Tomaszewsky JE et al "Use of Endorectal MR Imaging to Predict Prostate Carcinoma Recurrence after Radical Prostatectomy" Radiology 1998; 209:537-542


13) Kirkham AP, Emberton M, Hoh IM et al "MR Imaging of Prostate after Treatment with High-Intensity Focused Ultrasound" Radiology 2008; 246:83 3-844