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MRI findings of absorbable hydrogel spacer for prostate cancer therapy: a pictorial review

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Abstract

Prior studies have shown that dose-escalated radiation therapy for prostate cancer improves clinical outcomes. However, this is associated with increased rectal toxicity. Hydrogel spacer for prostate cancer therapy is an effective way of decreasing rectal toxicity in the late post-therapeutic stages. In some occasions, the gel spacer may not be placed symmetrically between the rectum and prostate. There are several forms of a malpositioned spacer, including lateral displacement, rectal wall infiltration, and prostate capsule infiltration. This manuscript is aimed at evaluating appropriately positioned and malpositioned gel spacers, primarily via magnetic resonance imaging. There are limited educational imaging guides that address what radiologists should evaluate on post-spacer placement imaging. This pictorial review will specifically evaluate post-injection pitfalls such as asymmetry, rectal wall infiltration, and subcapsular injection.

Key words: Prostate spacer—Gel—MRI—Asymmetry

Multiple studies have shown that dose-escalated radiation therapy for prostate cancer improves clinical outcomes. However, this is associated with increased rectal toxicity. Hydrogel spacer for prostate cancer therapy is a relatively efficient way of decreasing rectal toxicity. Not every patient with prostate cancer is a candidate for hydrogel spacer placement, although classification systems for those who would benefit have been described [1].

The general concept of the gel spacer is to reduce radiation dose to the rectum in patients undergoing radiotherapy [2, 3]. The spacing hydrogel is injected into the perirectal space under ultrasound guidance between the rectum and the prostate [4]. Apart from the reduced dose to the rectum, the spacer has been proven to reduce rectal toxicity in the late post-therapeutic stages. Secondary benefits include improved quality of life, specifically regarding urinary continence and sexual drive [5, 6]. Previous literature describes multiple biomaterials that have been injected into the perirectal space, including hyaluronic acid, collagen, and absorbable balloons; however, polyethylene glycol (PEG) hydrogels are most commonly used due to stability during radiation therapy and easy visualization on imaging. PEG hydrogels resorb after approximately 3 months.

The gel spacer is placed via a trans-perineal route using ultrasound guidance and per the manufacturer's instructions. In general, a transrectal ultrasound is introduced to visualize the prostate and rectum. Denovillier's fascia (retro-prostatic fascia) is identified via ultrasound, followed by direct local anesthetic infiltration. A needle is directed into the Denovillier's fascia at the midline and advanced to approximately mid-prostate gland level. About 25 cc of sterile saline is then injected to hydro-dissect and create a space in Denovillier's fascia. Approximately 5 cc each of liquid gel and polymerization accelerant material is then coinjected into this space using a dual chamber syringe, and the gel solidifies over a few seconds. Generally, approximately 1 cm of space is created between the prostate and rectum.

Several technical factors must be considered when placing the hydrogel spacer to optimize positioning in an ideal anatomic location. Prior research has estimated that up to 50% of procedures may result in at least some degree of asymmetry, with less than 2% having significant lateral displacement. The latter group experienced an increased rectal dose, relative to those with symmetric spacer placement. Asymmetry is not the only concern regarding malpositioning; rectal wall infiltration has also been described [7]. Additionally, prostate position variability must be considered during radiation therapy [8].

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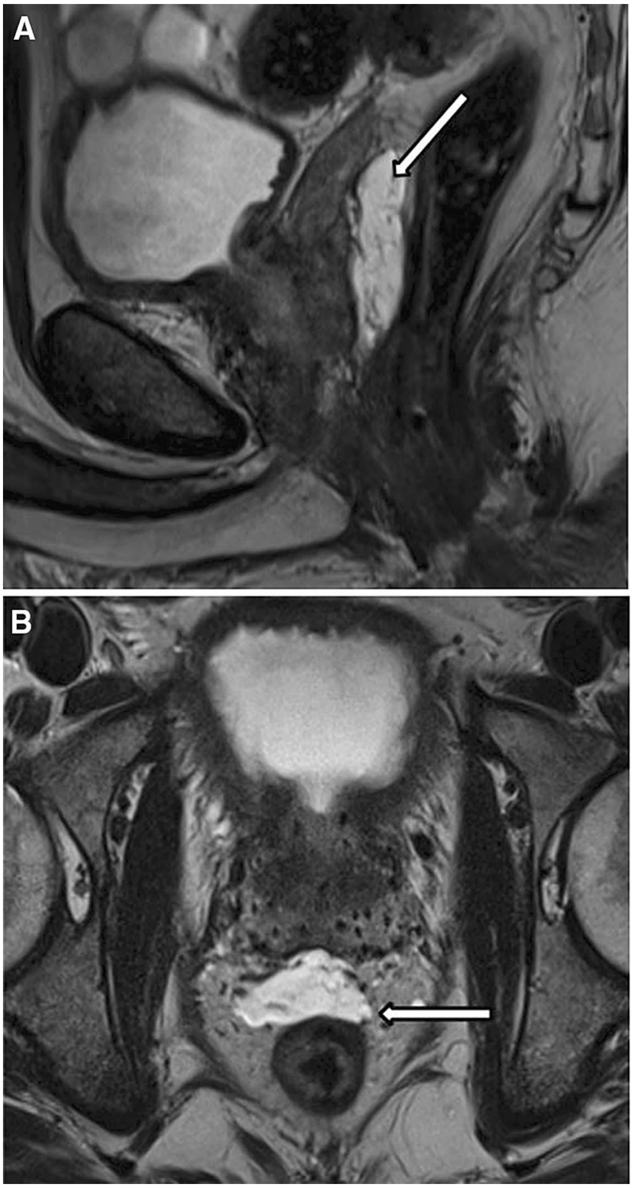

Fig. 1. Sagittal (**A**) and axial (**B**) T2W MR sequence demonstrating correct symmetric midline positioning of the gel spacer (white arrow) interposed between the anterior wall of the rectum and posterior margin of the prostate gland.

There are limited educational imaging guides that address what radiologists should evaluate on post-spacer imaging. Previous literature has described the critical role of magnetic resonance imaging (MRI) as well as the radiologist experience in evaluation of gel spacer positioning to avoid diagnostic error [9]. This pictorial review will include post-injection pitfalls such as asymmetry, rectal wall infiltration, and subcapsular injection.

At our institution, an MRI is performed after hydrogel spacer placement to delineate positioning prior to radiation therapy. Patients are imaged via a standard protocol, which includes axial, coronal, and sagittal T2/HASTE whole pelvis, axial and coronal T1 Fat-saturated pre- and postcontrast whole pelvis imaging, and axial DWI/ADC.

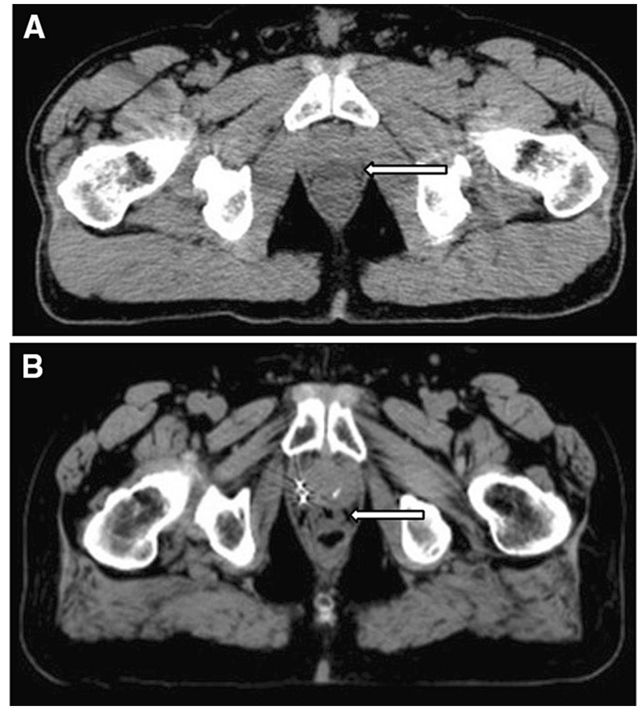

Fig. 2. Axial **A** CT image demonstrates normal appearing low attenuation gel spacer between the rectal wall and prostate gland (white arrow) and axial **B** CT image immediately following gel spacer placement demonstrates the low attenuation spacer and postprocedural gas.

The T2-weighted imaging is acquired with the following parameters: Axial acquisition, TR = 1600 ms, TE1 = 95 ms, ΔTE = 95 ms, 194 echoes per TR, matrix = 194×320, FOV = 285×380 mm and slice thickness = 5.0 mm. Sagittal acquisition, TR = 3610 ms, TE1 = 101 ms, ΔTE = 101 ms, 25 echoes per TR, matrix = 310×320, FOV = 200×200 mm and slice thickness = 3.0 mm. Coronal acquisition, TR = 4000 ms, TE1 = 101 ms, ΔTE = 101 ms, 25 echoes per TR, matrix = 272×320, FOV = 200×200 mm and slice thickness = 3.0 mm.

Though the axial and sagittal T2 images are the primary sequences utilized for interpretation, the additional sequences are added per our institutional protocol to aid radiation oncology with brachytherapy seed placement and radiation planning.

Normal placement

Hydrogel positioning is best demonstrated on T2-weighted magnetic resonance (MR) imaging. Ideal position of the gel spacer is within the perirectal fat, between the anterior wall of the rectum and posterior margin of the prostate gland (Fig. 1). The thickness of the gel spacer should be symmetric on both sides of the rectum, which is best demonstrated on axial imaging. The gel spacer should span the entire length of the prostate gland from base to apex, which is best demonstrated on sagittal imaging. The hydrogel spacer is difficult to delineate on CT imaging given relative isodense appearance in relation to the prostate gland (Fig. 2). The radiologist should comment on spacer positioning, including symmetry, recto-prostatic distance, and the craniocaudal span. Variations from the normal expected location, including asymmetry, incomplete coverage or complications should be described in more depth. Lastly, the circumscribed T2 hyperintense gel spacer should not be mischaracterized as a cystic pelvic mass due to the similar appearance. Understanding the MRI appearance and expected location after placement will assist in that interpretation.

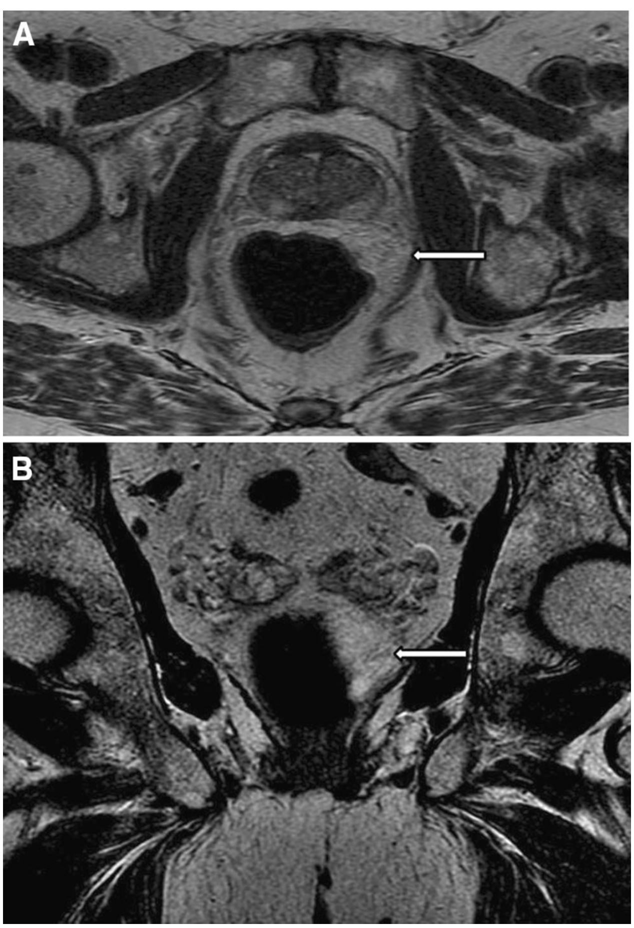

Fig. 3. Axial (**A**) and coronal (**B**) T2W MR sequences demonstrating malposition of the gel spacer (white arrow), slightly asymmetric to the left, resulting in a small portion of the anterior wall of the low rectum on the right not being covered by the gel spacer.

Asymmetry

Asymmetry of the PEG hydrogel spacer is a relatively common finding. Grading the asymmetry is important for the radiation oncologist, as recent studies have demonstrated that significant lateral displacement (> 2 cm) has been associated with increased rectal toxicity [7]. Axial (Fig. 3A) and coronal (Fig. 3B) T2-weighted MR images of asymmetric gel spacer distribution is provided.

Rectal wall infiltration

Due to technical factors such as limited pelvic evaluation via sonographic approach, rectal wall infiltration can occur during hydrogel placement. Sagittal (Fig. 4A) and axial (Fig. 4B) T2-weighted images demonstrate gel spacer infiltration within the anterior rectal wall. An additional case of rectal wall infiltration is also provided (Fig. 5). It is important to delineate rectal wall infiltration given excess toxicity with even mild infiltration into the adventitia of the rectal wall. The excess toxicity is secondary to the lack of displacement of the rectum to the prostate after infiltration. Complete infiltration of

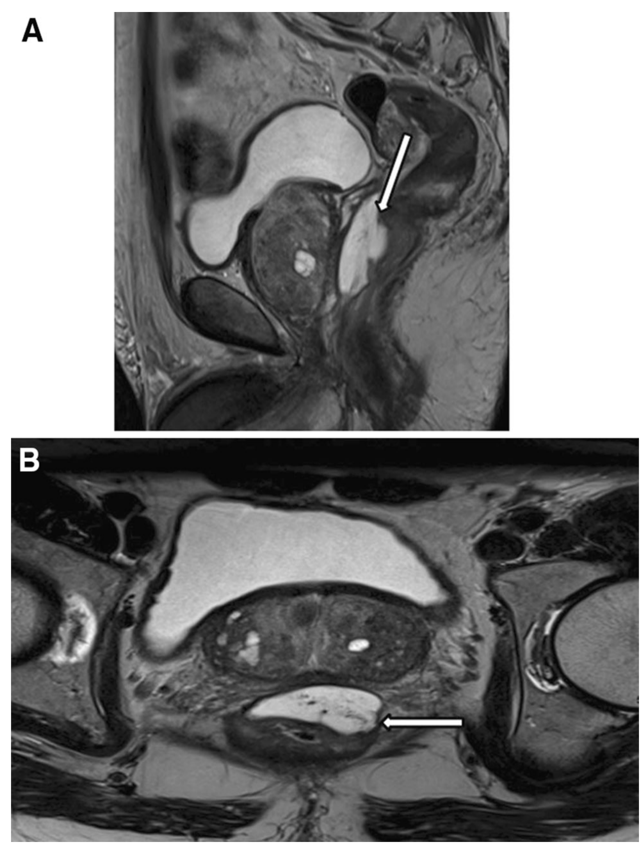

Fig. 4. Sagittal (**A**) and axial (**B**) T2W MR sequences demonstrating malposition of the gel spacer (white arrow), infiltrating the anterior rectal wall.

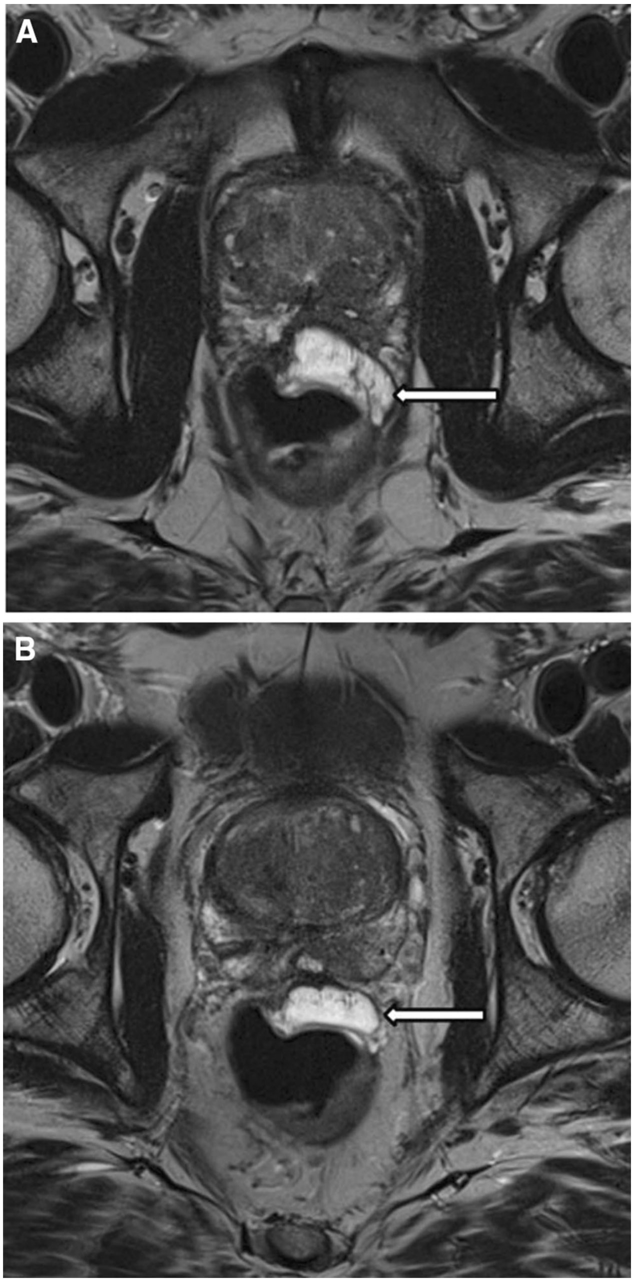

Fig. 5. Axial T2W MR sequences demonstrating malposition of the gel spacer (white arrow), infiltrating the anterior rectal wall.

the muscularis or mucosal layers raises concerns about proceeding with the planned radiation therapy. At our institution, it is recommended to refrain from treatment until the gel is fully re-absorbed, approximately 3-6 months later. Utilizing a new spacer is generally not elected due to concerns for fibrosis, although it is theoretically possible.

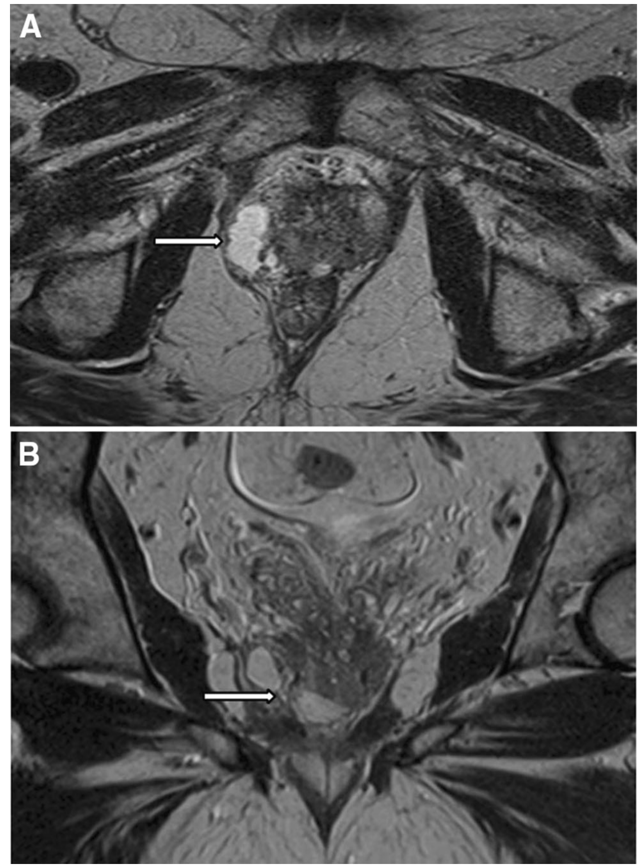

Fig. 6. Axial (**A**) and coronal (**B**) T2W MR sequences demonstrating malposition of the gel spacer (white arrow), with asymmetric right lateral subcapsular infiltration of the prostate gland.

Prostatic subcapsular infiltration

Similar to rectal wall infiltration, there is a potential for subcapsular infiltration of the prostate gland. Axial (Fig. 6A) and coronal (Fig. 6B) T2-weighted images demonstrate right lateral asymmetric gel spacer distribution with associated subcapsular prostatic infiltration. In our single case of subcapsular infiltration, the patient experienced mild dysuria and urinary frequency after treatment.

Conclusion

Hydrogel spacer placement for prostate cancer treatment is widely implemented, and there is a resultant need for understanding the ideal placement and potential malposition. There are numerous sites of potential malpositioning secondary to technical factors, although any positioning of the spacer outside of the expected location may result in reduced efficacy. There have been previous descriptions of what radiologists can expect, despite limited radiographic correlation. The goal of this pictorial review is to educate radiologists on the appropriate positioning of hydrogel spacer and potential complications, which can be seen on MRI.

Compliance with ethical standards

Funding This study contains no funding.

Conflict of interest Aaron Rohr declares that he has no conflict of interest. Kyle Werth declares that he has no conflict of interest. Xinglei Shen declares that he has no conflict of interest. Zachary Collins declares that he has no conflict of interest. Shelby Fishback declares that she has no conflict of interest. Jill Jones declares that she has no conflict of interest. Ryan Ash declares that he has no conflict of interest. Vanessa Williams declares that she has no conflict of interest.

Ethical approval This article does not contain any studies with human participants performed by any of the authors.

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