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Magnetic resonance imaging features of pubic symphysis urinary fistula with pubic bone osteomyelitis in the treated prostate cancer patient

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Abstract

Introduction Pubic bone osteomyelitis with pubic symphysis urinary fistula represents a debilitating complication of radiation and ablative treatments for prostate cancer. The definitive radiographic diagnosis of this clinical entity is not described. In this study, we characterize the plain film and magnetic resonance imaging findings of pubic osteomyelitis.

Materials and Methods We reviewed a database of prostate cancer survivors with diagnosed pubic osteomyelitis from 2011 to 2015. These patients underwent pelvic plain radiographs and magnetic resonance imaging with T1-weighted and fat-suppressed T2-weighted fast spin echo sequences. Intravenous gadolinium was utilized. The diagnosis was verified with extirpative surgery. 16 patients with diagnosed pubic osteomyelitis from 2011 to 2015 underwent imaging at our institution.

Results All patients demonstrated increased signal on T2- weighted sequences and decreased signal on T1-weighted sequences along the pubic symphysis and the marrow of the involved pubic rami. Inflammatory myositis with diastasis of the pubic symphysis and cortical bone erosion were identified in the majority of patients. Fluid collections were identified in 75% of patients. 63% of conventional radiographs demonstrated no radiographic evidence of pubic osteomyelitis.

Conclusion Magnetic resonance imaging of pubic symphysis osteomyelitis in the prostate cancer survivor is characterized by high signal on T2-weighted images and low signal on T1-weighted images of the involved pubic rami, with the majority of patients demonstrating regional myositis. Imaging data combined with clinical assessment should prompt diagnosis and management of pubic osteomyelitis. Conventional radiography is generally insensitive to these findings. We consider magnetic resonance imaging to be the definitive diagnostic modality for this clinical entity.

Keywords Magnetic resonance imaging · Pubic osteomyelitis · Prostate cancer · Prostate cancer survivor · Cancer survivorship

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Introduction

Pubic disorders related to treatment for prostate cancer represent an increasingly reported complication. In particular, pubic bone osteomyelitis with an associated urinary fistula represents a debilitating condition characterized by pelvic pain, difficulty with ambulation and recurrent genitourinary infections.

Pubic bone osteomyelitis is defined as an infection of the pubic symphysis and pubic rami and is commonly associated with a urinary fistula between the bladder or prostate bed and pubic symphysis joint which facilitates translocation of bacteria from the urinary system to the pelvic bones. This combination of findings is typically seen in prostate cancer patients after pelvic radiotherapy and subsequent urinary tract instrumentation, usually in the setting of the treatment of prostatic urethral stenosis or a bladder neck contracture [1–3]. Pelvic radiation enhances bone susceptibility to microbial infections due to attenuated wound healing mechanisms [4]. Other urologic causes of pubic osteomyelitis described in the literature include transurethral resection or photovaporization of the prostate, chronic indwelling catheters and bone-anchored slings for stress urinary incontinence [5–8].

Although computed tomography, conventional radiography, and tagged white blood cell nuclear medicine scan represent well known diagnostic tests in patients suspected of having musculoskeletal infections, magnetic resonance imaging (MRI) offers some advantages for the diagnosis of osteomyelitis as it can reveal the extent of osseous involvement in addition to concomitant soft tissue abnormalities [9–11]. However, the common imaging findings in the treated prostate cancer patient with pubic symphysis osteomyelitis are not fully characterized using this modality. While many authors have previously published on the computed tomography finding in post-radiotherapy pubic osteomyelitis in patients with cervical, vulvar, or bladder malignancy, there remains scant literature analyzing the MRI findings in the prostate cancer survivor with pubic symphysis osteomyelitis [12, 13]. Given the paucity of literature, we seek to further describe and characterize the plain film radiographic and MRI manifestations of this patient population with proven fistulous disease after surgical intervention.

Materials and methods

Study population and definition

We conducted a review of an institutional review board approved database of treated prostate cancer patients diagnosed with pubic symphysis osteomyelitis from January 2011 to August 2015. In order to assess which patients could be included in the initial study group, the database was queried for patients with clinical symptoms of pubic bone osteomyelitis (including chronic pain in the pelvic region, tenderness to palpation on the pubic symphysis, difficulty walking or flexion of the leg at the hip, and presence of abscess drainage to the anterior abdominal wall or anterior thigh), as well as histologic and/or microbiologic confirmation of pubic bone osteomyelitis after surgical removal, which served as the main inclusion criteria. To ensure homogeneity in MRI protocol and interpretation, patients that underwent imaging at outside institutions were excluded from analysis. Clinical and demographic data were extracted, including information on the presence or absence of diabetes due to its known impact on wound healing.

After a diagnosis was established with clinical and radiographic examination, a multidisciplinary algorithmic approach to treatment was instituted, which consists of intravenous antibiotic therapy, temporary urinary diversion with catheter drainage and hyperbaric oxygen treatment in hyperbaric naïve patients. Patients with a suboptimal response to this conservative approach were offered definitive surgical management. Failures were defined as patients with persistent pelvic pain and those with interval development of suppurative infections while on antibiotic therapy. Definitive surgical management consisted of resection of the pubic symphysis and involved pubic rami until all grossly infected bone was removed. Supratrigonal cystectomy or cystoprostatectomy (if the prostate was in situ) was performed along with urinary or fecal diversion in cases where the bladder or rectum was not deemed salvageable respectively.

Of the initial group of 23 treated prostate cancer patients in our series who met initial inclusion criteria of pubic symphysis osteomyelitis, we identified a final study population of 16 patients with pubic bone osteomyelitis who underwent MRI performed at our institution and subsequently underwent surgical treatment.

Imaging

Patients with clinical evidence of pubic symphysis osteomyelitis, as defined above, underwent multiplanar multiecho MRI of the pelvis. The MRI protocol consisted of axial, sagittal, and coronal T1-weighted and fat-saturated T2-weighted fast spin echo or short tau inversion recovery (STIR) sequences. In addition, axial and coronal T1-weighted images were performed approximately 2 min after administration of a standard weight-based dose (0.1 mmol/kg) of intravenous gadolinium-based contrast (gadobenate dimeglumine, Multihance, Bracco

Diagnostics, Monroe Township, NJ, USA) as per our standard clinical protocol for evaluation of patients with suspected osteomyelitis. Our standard clinical imaging protocol for suspected osteomyelitis/abscess workup includes pre-contrast and post-contrast imaging as post-contrast enhancement increases the sensitivity for detecting and characterizing fistulas and abscesses/fluid collections. It also increases specificity in the assessment of the surrounding soft tissues. Interpretation of images was performed by one of four board-certified, fellowship-trained radiologists with subspecialty expertise in musculoskeletal imaging with at least 3 years of post-fellowship experience. Note was made for the presence of fistulas (defined as low signal intensity centrally with enhancement of the tract walls on T1-weighted, fat-suppressed, post-gadolinium imaging [14]), cortical erosion of the parasymphyseal bone with diastasis of the pubic symphysis, fluid collections, abscess, abnormal marrow signal intensity, along with inflammatory changes to the muscle and tendinous insertions. Patients also underwent conventional radiography of the pelvis in the anterior–posterior projection as part of our baseline characterization.

Statistical analysis

Descriptive statistics were utilized to summarize radiographic findings. Continuous variables were documented as mean ± standard deviation (SD) for parametric data and median ± interquartile range for nonparametric data. Frequency data are presented as percentages. Fisher's exact test was used to assess for differences in imaging characteristics in patients based co-morbidities. Statistical analysis was performed with JMP Pro 12 (SAS Institute, Cary, NC).

Results

Study population

Sixteen patients with pubic bone osteomyelitis who met our inclusion criteria were included in the final study population. All patients underwent pelvic radiotherapy consisting of external beam radiotherapy only ($n = 3$), brachytherapy with external beam radiotherapy ($n = 6$), primary external beam radiotherapy with salvage cryotherapy ($n = 3$), and external beam radiotherapy after prostatectomy as adjuvant ($n = 2$) or salvage therapy ($n = 2$). The median age of our cohort was 72 years (IQR 66–78). 14 of 16 patients had prior laboratory investigations available, demonstrating a mean C-reactive protein of 10.9 ± 7.9 mg/dL (normal range < 1 mg/dL). Table 1 highlights the clinical and demographic characteristics of our study population.

Table 1 Demographic and clinical characteristics of patients with pubic symphysis osteomyelitis ($n = 16$)

	Variable	No. (%)
Co-morbidities		
	Diabetes	10 (62.5)
	Hypertension	7 (43.8)
	Smoking history	7 (43.8)
	End stage renal disease	0 (0.0)
Treatment for prostate cancer		
	Prostatectomy + external beam radiotherapy	4 (25.0)
	EBRT + salvage cryotherapy of the prostate	3 (18.75)
	EBRT + brachytherapy	6 (37.5)
	External beam radiotherapy only	3 (18.75)
Bladder outlet procedure after prostate cancer treatment	Prior endoscopic intervention for bladder outlet obstruction after treatment of prostate cancer	12 (75.0)

Osseous findings

Increased signal on the T2-weighted images (resembling edema-like signal) and decreased signal on the T1-weighted sequences of the parasymphyseal bone (relative to skeletal muscle) was noted in all patients on MRI (Fig. 1). Cortical erosion with associated diastasis of the pubic symphysis was appreciated in 10 patients (63%). Pubic rami fractures were identified in one patient. In general, post-gadolinium enhancement is not critical for diagnosing osteomyelitis as demonstrated in our study and others [15–17]. The most important diagnostic imaging features are the features described above, specifically, confluent decreased signal intensity on the T1-weighted images (relative than skeletal muscle) and cortical irregularity/destruction with concurrent edema-like signal on the fluid-sensitive MRI sequences (Table 2). Correlative findings on conventional radiographs to suggest osteomyelitis were recognized in 6 patients. The most common plain film radiographic features noted in our cohort included widening of the pubic symphysis, erosion of the cortical margins, and/or adjacent soft tissue changes.

Non-osseous findings

Most common non-osseous findings seen were inflammatory changes to the surrounding muscle compartments and

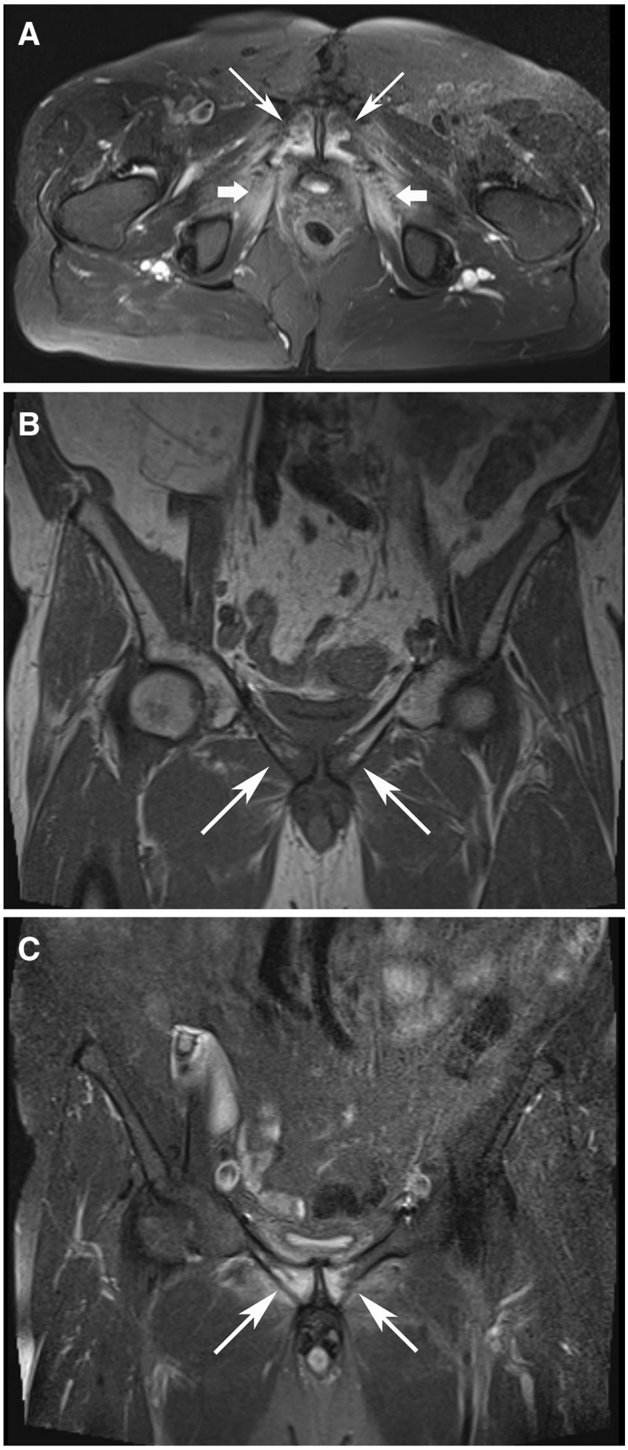

Fig. 1 Seventy-four-year-old male with history of radical retropubic prostatectomy and adjuvant radiation therapy with pubic osteomyelitis. **a**, **b** Axial and coronal fat-saturated T2-weighted MR images with of the pelvis demonstrating increased T2 signal in the parasymphyseal bony structures relative to skeletal muscle (angled white arrows). The images also reveal surrounding soft tissue inflammatory change and myositis (horizontal block white arrows). **c** Corresponding coronal T1 weighted image shows infiltrative signal hypointensity in the parasymphyseal osseous structures (angled white arrows)

Table 2 Osseous and non-osseous MRI findings associated with pubic symphysis osteomyelitis in the treated prostate cancer patient

Osseous findings of osteomyelitis	
T1-weighted	*Confluent intramedullary signal hypointensity*
T2-weighted	Intramedullary signal hyperintensity
T1-weighted, post-gadolinium	Confluent intramedullary enhancement
Other imaging features	Cortical erosion/destruction
Non osseous soft tissue findings	
Fluid collection	
T1-weighted	Focal signal hypointensity
T2-weighted	*Focal signal hyperintensity*
T1-weighted, post-gadolinium	*Peripheral rim enhancement*
Inflammatory Myositis	
T1-weighted	Loss of normal fibroadipose architecture
T2-weighted	*Infiltrative intramuscular signal hyperintensity*
T1-weighted, post-gadolinium	Infiltrative intramuscular enhancement
Fistula	
T1-weighted	Linear signal hypointensity
T2-weighted	Linear signal hyperintensity
T1-weighted, post-gadolinium	*Enhancement of the fistula wall/border*

Italicized text refers to a particularly helpful imaging sequence/imaging finding in each category

fluid collections. A total of 13 fluid collections were noted in 12 of the 16 patients (75%). These were identified in the parasymphyseal space ($n = 4$), periprostatic space ($n = 4$), rectus abdominis ($n = 2$), adductor compartment (Fig. 2) ($n = 1$), perineum ($n = 1$), and retrovesical space ($n = 1$). Post-gadolinium imaging was helpful to discern a true fluid collection/abscess from phlegmonous inflammatory change, the latter of which will have internal enhancement rather than rim enhancement which is more characteristic of the former [18].

Eleven of sixteen patients had increased T2-weighted signal suggestive of inflammatory myositis along the pelvic musculature, with the adductor compartment ($n = 6$), pectineus ($n = 2$), gracilis ($n = 2$), or the obturator musculature ($n = 3$) representing the most common locations. The diagnosis of myositis was most evident as edema-like signal within the muscles on fluid-sensitive MRI sequences; of note, post-gadolinium imaging was not as critical for making the diagnosis of myositis as compared with making the diagnosis of fluid collections as described above. Partial tears in the tendinous insertions were recognized in the adductors in four patients (25%). 8 patients

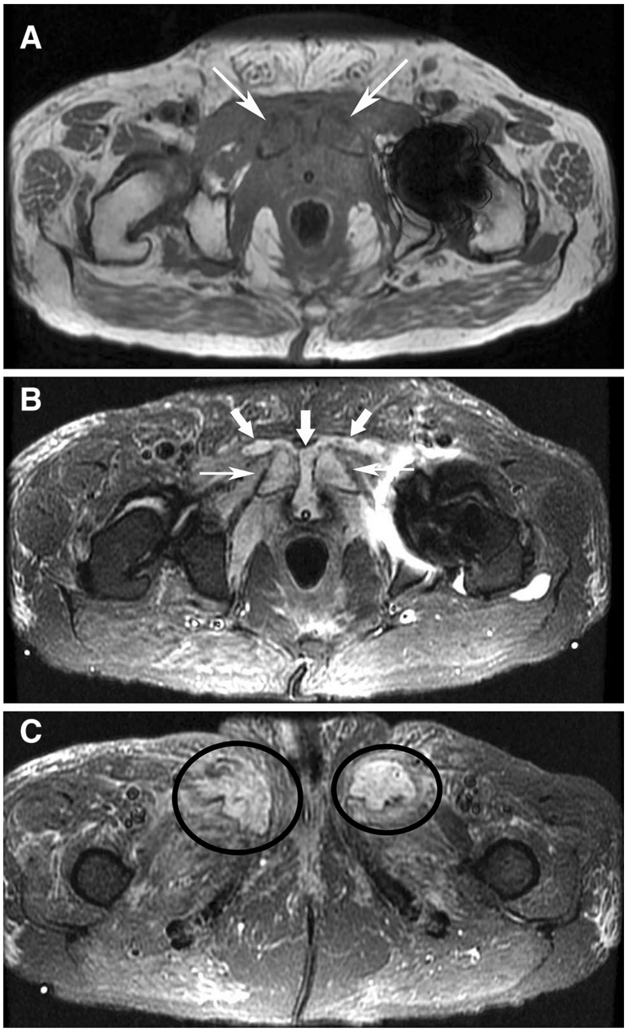

Fig. 2 Sixty-six-year-old male with history of radical retropubic prostatectomy and adjuvant radiation, now with pubic bone osteomyelitis and bilateral adductor abscesses. **a** Axial T1-weighted MR image of the pubic symphysis demonstrating significant intraosseous signal hypointensity and cortical disruption (angled white arrows). **b** Axial STIR-weighted MR image of the pubic symphysis shows increased signal in the parasymphyseal osseous structures (angled white arrow). There is fluid in the pubic symphysis dissecting into the soft tissues anteriorly (block white arrows). The image also reveals a left hip arthroplasty and trochanteric bursitis. **c** Axial STIR-weighted MR image of the same patient centered at the level of the adductor muscle groups shows bilateral intramuscular abscesses (circled) with diffuse surrounding myositis

(50%) had a readily identifiable fistula to the pubic symphysis from the bladder ($n = 2$), prostate ($n = 3$), and membranous urethra ($n = 1$) (Fig. 3). Additional fistulas were identified as follows: parasymphyseal-cutaneous fistula ($n = 1$) and recto-vesical-pubic symphysis-cutaneous fistula ($n = 1$). Fistula can be difficult to elucidate on non-contrast MRI and often become more apparent on post-contrast images. Fistulas often appear as a general area of inflammatory soft tissues on non-contrast images and after

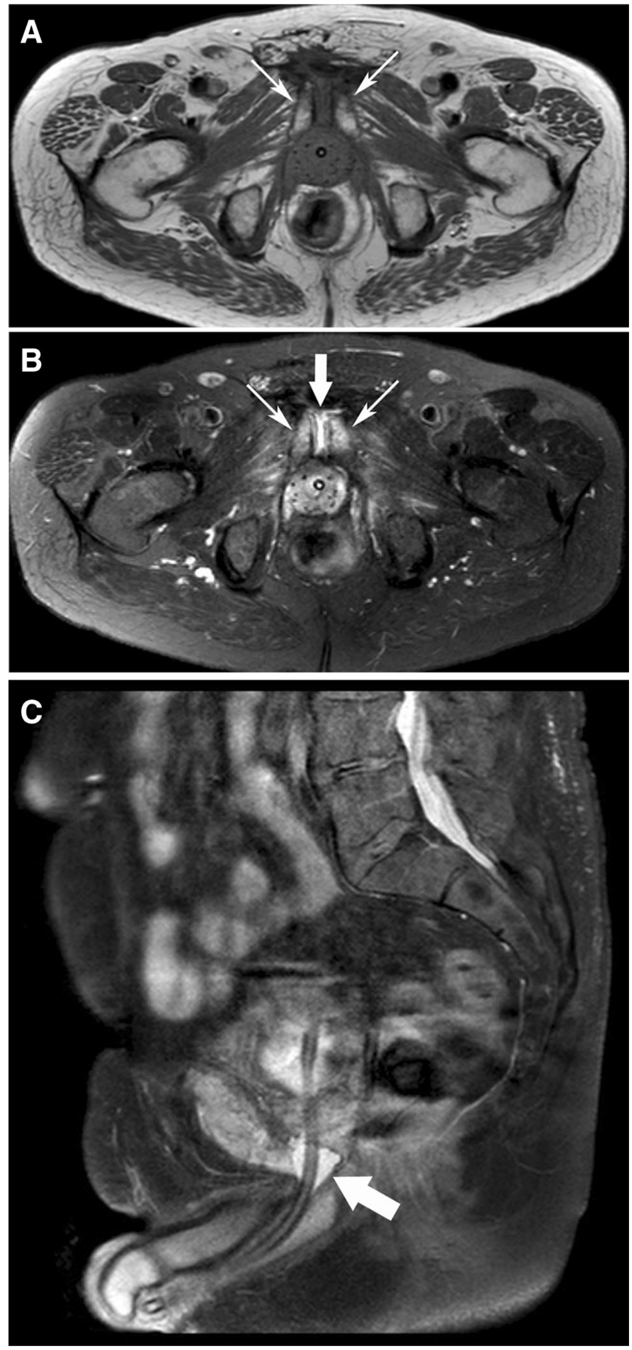

Fig. 3 Seventy-eight-year-old male who underwent prostate brachytherapy complicated by urethral stricture requiring multiple dilations and pubic osteomyelitis with urethral fistula. **a** Axial T1-weighted MR image of the pelvis shows subtle intraosseous signal hypointensity in the parasymphyseal bone with cortical irregularity and disruption on the left (angled white arrows). **b** Axial fat-saturated T2-weighted MR image in the same patient demonstrates parasymphyseal osseous edema (angled white arrows), surrounding myositis, and fluid in the pubic symphysis (block white arrow). **c** Sagittal, fat-saturated T2-weighted MR image which illustrates a periurethral fluid collection (block white arrow) which was deemed at surgery to also have a fistulous connection extending anteriorly toward the pubic symphysis

contrast administration, fistulas will have distinct morphologic features including enhancement of the fistula borders/walls [14].

There was no difference in the presence of fistulous disease (83.3% vs 70%, $p = 1.0$, two tailed Fisher's Exact Test) or fluid collections (50% vs 50%, $p = 1.0$, two tailed Fisher's Exact Test) between patients with diabetes compared to non-diabetic patients.

Discussion

Pubic bone osteomyelitis with an associated urinary fistula in the treated prostate cancer patient represents a rare but debilitating condition, with increasing reports in the literature of the significance of this condition. Recognition of the clinical symptoms and imaging findings are critical to establishing a diagnosis and providing appropriate treatment that can alleviate the disabling pain and decreased quality of life noted in this patient population. We describe the MRI characteristics in treated prostate cancer patients with histologic and/or microbiologic confirmed pubic osteomyelitis after surgical treatment. The findings from our study will hopefully provide the clinician treating patients with this condition further insight into anticipated radiographic characteristics of this disease, inform radiologists of the importance of accurately making this diagnosis and characterizing its associated findings, and better facilitate counseling of the medical and surgical interventions required.

MRI provides optimal soft tissue resolution to allow ascertainment of potential fluid collections, the extent of osseous involvement and inflammatory changes of the surrounding musculature. It can also detect changes in the signal of bone in acute or chronic cases of osteomyelitis that are not visible on CT, plain radiography, and 3-phase 99mTc bone scanning [19–21]. It is noted in our study that 63% of plain radiographs demonstrate no imaging characteristics of pubic osteomyelitis. The universal finding of high signal on T2-weighted images and low signal intensity on T1-weighted images on MRI reflects alteration of marrow signal intensity, due to the edema and exudate in the medullary space [16, 20]. While this is a non-specific finding in isolation and is not pathognomonic for osteomyelitis (patients with osteitis pubis can also have changes in marrow signal intensity in the setting of a non-infectious, inflammatory process), we still feel it to be very helpful in the diagnosis due to its universal prevalence in our patient population [22]. The clinical history, physical examination, presence of fistula and other soft tissue findings on MRI should assist the clinician establishing a diagnosis of pubic osteomyelitis and should be information provided to the radiologist to optimize diagnosis. Although it has been previously demonstrated that fat-suppressed contrast-enhanced MRI imaging was more specific than non-enhanced MRI imaging in diagnosing osteomyelitis, it should be noted that the diagnosis of osteomyelitis can still be made in the absence of intravenous contrast administration [23, 24].

Our findings are in concordance with Bugeja and others, who recently described their experience with fistulas in the treated prostate cancer patient after radiotherapy. In their study, MRI was utilized in all cases and fistulous disease was identified in all patients. The fistulas originated at the level of the vesicourethral anastomosis and tracked anteriorly into and through the pubic symphysis in patients who had a prior radical prostatectomy. In those with the prostate in situ after radiotherapy, the authors noted this area was often reduced to a fluid filled cavity which was in continuity with a cavitating pubic symphysis. However, it should be noted that there was limited/no mention of the extent of bone involvement on MRI in their study population [1].

Imaging in pelvic osteomyelitis in the setting of prior radiotherapy for malignancies other than prostate cancer has been described. Wignall and authors previously described the computed tomographic feature of post-radiotherapy pubic symphysis osteomyelitis in patients with bladder or uterine cancer. In their cohort, seven patients were identified at a mean interval of 13.9 years from the time of prior pelvic radiotherapy to the presentation with osteomyelitis. Imaging revealed destruction of the symphysis pubis in all patients, with the majority of patients having an abscess ($n = 6$) or inflammatory soft tissue mass around the involved bone ($n = 5$). Of note, the inciting factors promoting the development of osteomyelitis in their study population vary from our cohort. We believe the incidence of pubic osteomyelitis in our cohort is largely due to urinary tract instrumentation in the setting of prior pelvic radiotherapy based on the high association of this in our population. Wignall et al. population's presentation to their provider was due to clinical signs of fistula from the bone to the large or small intestine ($n = 3$), vagina ($n = 2$), or recto-vaginal-pubic symphysis fistula ($n = 1$), rather than pelvic pain or recurrent urinary tract infections which is the case in our population [13].

We do acknowledge some limitations of our study, which include the small sample size, lack of consensus readings and standardized criteria for categorization of imaging findings, as well as the inherent issues of sampling and information bias common with retrospective studies. However, despite our small sample size, which is due to combination of the rarity of this condition and our stringent inclusion criteria with surgical confirmation, we feel that our results are generalizable to other patient populations and raise awareness of this important condition. Given how infrequently this illness had been described previously in the literature, future multi-reader/multi-institutional efforts, standardized imaging approaches, and increasing recognition and treatment of this likely underreported condition will prove useful in the continuing accurate characterization of this disease. With regard to standardizing the imaging approach for this patient population and specifically making the diagnosis of fistulae in these cases, we feel that the interpreting radiologist should first look for confluent hypointense medullary signal on the T1-weighted images with edema-like signal on the fluid-sensitive sequences to begin to invoke the diagnosis of osteomyelitis. In addition, the reader should assess the bony cortex for indistinctness or destruction as an important imaging finding of this condition. At our institution, we feel that post-contrast images are key in the further assessment of fistulas and abscesses. Contrast enhancement increases the sensitivity for detecting and characterizing fistulas and abscesses/fluid collections. It also increases specificity in the assessment of the surrounding soft tissues. Again, this approach needs validation in larger studies to demonstrate its value but we feel that this approach would help ensure that this diagnosis is made more accurately and more often in these patients.

In conclusion, the presence of pubic symphysis osteomyelitis in the treated prostate cancer patient is typified on MR imaging by abnormal marrow signal intensity, cortical bone erosion and diastasis of the pubic symphysis in the majority of patients. As is well known in clinical practice, plain radiography is insensitive for the diagnosis of osteomyelitis. As such, MRI should be used as the imaging modality of choice in this patient population to establish a diagnosis of osteomyelitis and facilitate the identification of associated findings as a significant percentage of patients in this population will have important non-osseous findings such as fistula or fluid collections that can alter the plan of care of the treating clinician. Awareness of this condition and its associated findings will aid radiologists in imaging this challenging patient population more effectively.

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Compliance with ethical standards

Conflict of interest Nothing relevant to disclose for all authors

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study is retrospective in its design and for this type of study formal consent is not required. An appropriate institutional review board approved this study.

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