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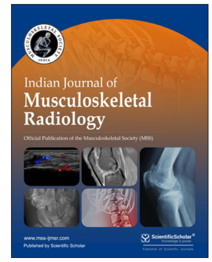

Pictorial Review

Magnetic Resonance Imaging of Complications in Total Knee Arthroplasty: A Pictorial Essay

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ABSTRACT

With the ever-increasing number of total knee replacement, the demand for early diagnosis of post arthroplasty complications has increased as well. The various complications associated with total knee replacement include bursitis, tendinitis, periprosthetic fracture, infection, instability, malalignment, loosening, prosthesis fracture, osteolysis, soft tissue impingement, and extensor mechanism problems. Radiographs and nuclear imaging, earlier the mainstays for evaluation of post arthroplasty knee, have vast limitations, especially in evaluating the soft tissue details which account for the symptoms in a significant number of patients. Magnetic resonance with special modifications, i.e. metal artifact reduction sequences, is of immense help in a detailed evaluation of these soft tissue complications and is advisable in all patients where the cause cannot be determined on plain radiographs.

Keywords: Arthroplasty knee, Artifacts, Complications, Magnetic resonance imaging, Musculoskeletal abnormalities

INTRODUCTION

Total knee arthroplasty (TKA) is a commonly performed procedure surpassing total hip arthroplasty in numbers that are ever-rising with increasing patient satisfaction and life spans.[1] The most common indication is osteoarthritis, followed by with rheumatoid arthritis, seronegative arthritides, crystal deposition diseases, and hemophilia.

TKA helps a large a portion of especially the geriatric population to get back on their feet each year with an appreciable overall success rate. The average age of the prosthesis has also increased to around 15–20 years. And as expected, with the increase in the number of surgeries and the longevity of implants, the incidence of failures and complications is also rising leading to the need for early and prompt diagnosis.

The various complications associated with TKR include bursitis, tendinitis, stress fracture, periprosthetic fracture, infection, instability, malalignment, aseptic loosening, prosthesis fracture, polyethylene wear, osteolysis, arthrofibrosis, soft tissue impingement, avascular necrosis of the patella, and extensor mechanism problems such as patellar maltracking.[2,3]

Earlier the imaging evaluation of painful TKA was limited, with conventional radiographs and nuclear imaging being the mainstay.[4] Lately, with the advent of specialized metal artifact reduction sequences (MARS) and newer instrumentation, the challenge of susceptibility artifacts due to the metal implants has largely been overcome during magnetic resonance imaging (MRI).

Learning objectives

MR, with its inherent improved soft tissue delineation, provides a more accurate diagnosis of the underlying complications.[5,6] Despite this, the role of MR in painful TKA has been relatively unexplored.

The aim of this pictorial essay is to provide an insight into the MRI features of the various complications associated with TKA.

MRI evaluation of post arthroplasty knee

This essay elaborates the MRI findings in painful knees following TKA.

The description is based on scans done on a 1.5T scanner (Sonata, Siemens, Germany). There is a description of MRI findings in 29 painful knees in 28 patients following TKA.

The symptomatic knee was scanned separately in a flex coil. All subjects underwent MRI using standard clinical protocols optimized to minimize metallic susceptibility artifact.

Fast spin-echo T1W and T2W images were obtained in the coronal, axial, and sagittal planes with the frequency encoding direction oriented away from the tissues of interest. The parameters for 1.5T scans were as follows: TR range, 400–4000 ms; TE range, 8–102 ms; bandwidth 600–751; FOV, 100–200 mm; number of signals acquired, 2; acquisition matrix, 256–320 (frequency), 80–100 (phase); and slice thickness, 4 mm. A fast inversion recovery sequence was performed in the coronal plane using the following parameters: TR/TE, 4200/53 and inversion time, 130 ms.

The images from each sequence were loaded on a workstation (Osirix, IMAC, Apple, Inc, USA) and reviewed in detail for the following: Loosening, infection, arthrofibrosis, osteolysis, fracture, bursitis, muscle tear, and other patellofemoral compartment abnormalities. The plain radiographs were also evaluated in conjunction.

Imaging appearance of various complications

Periprosthetic infection is seen as ill-defined marrow signal abnormality with edema [Figures 1 and 2] usually with associated collection/joint effusion and synovial hypertrophy. The pattern of synovial hypertrophy also helps in differentiating between infective and reactive causes with lamellated synovial hypertrophy [Figure 3] more likely associated with infection.[7] Presence of enlarged lymph nodes added to the level of confidence.

Arthrofibrosis was defined as ill-defined low signal soft tissue within the joint space.

The fracture was defined as either complete bony discontinuity [Figure 4] or a linear T1/T2 hypointensity with surrounding edema. Focal area of marrow edema without an obvious hypointense line was also labeled as a stress fracture/reaction.

Bone resorption was defined as a greater than 2 mm area of intermediate to high signal-intensity marrow replacement of the hyperintense fatty marrow at the bone prosthesis interface. Surrounding marrow edema if present suggests the presence of associated infection [Figure 5]. A <2 mm layer of signal abnormality between the host bone and the implant or cement is attributed to fibrous membrane formation, which usually has a smooth margin as against resorption which usually shows irregular margins.[8]

The term loosening was reserved for cases where bone resorption had a circumferential distribution [Figure 3] and associated implant displacement or rotation was seen.

Osteolysis / particle disease was defined as a focal usually geographic area of intermediate- signal-intensity marrow

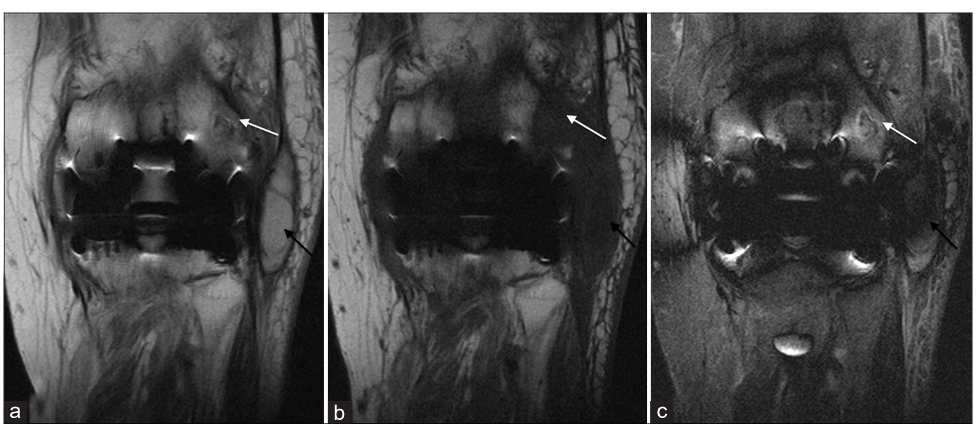

Figure 1: (a-c) Periprosthetic osteomyelitis with abscess: T2W (a), T1 W (b), and STIR (c) coronal images showing osteolysis with altered marrow signal involving the lateral femoral condyle (white arrow) with an associated collection along the lateral aspect (black arrow) of the knee.

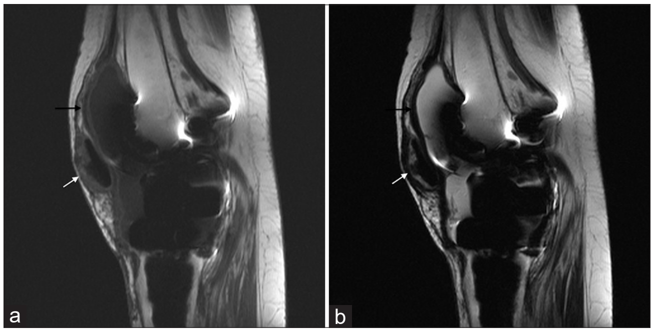

Figure 2: (a and b) Patellar osteomyelitis with synovitis: T1W (a) and T2W (b) sagittal images showing altered patellar signal (white arrow) with osteolysis along the patellar button and joint effusion with a T1 hyperintense rim (black arrow).

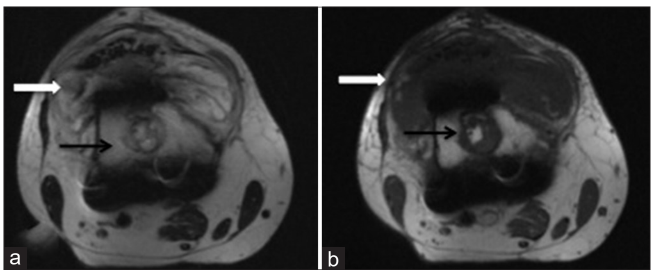

Figure 3: (a and b) Periprosthetic infective synovitis with loosening of femoral component: T1W (a) and T2W (b) axial images showing joint effusion with lamellated synovial thickening (open arrow). Circumferential osteolysis surrounding the stem of the femoral prosthesis is also seen (black arrow).

replacing the hyperintense fatty marrow. Associated synovitis, usually with a low to intermediate signal intensity, frond like pattern and debris[7,8] was also seen.

Patellar complications included instability, fracture, loosening or rupture of the patellar prosthetic button, impingement, osteonecrosis, quadriceps tendon tear, and patellar tendon tear/fibrosis.

Patellar instability was defined as the abnormal medial or lateral tilt of the patella or dislocation (medial, lateral, caudal, or cranial). On the axial images, the central ridge of the patella should normally lie at or medial to the bisector of the trochlear angle and deviation from this was defined as subluxation/dislocation.[3] Caudal or cranial positioning was defined using the Insall-Salvati index,[9] which is the ratio between the length of the patellar tendon (TL) and the maximum vertical length of the patella (PL) (>1.43 was defined as superiorly positioned or patella alta and <0.71 as inferiorly positioned or patella baja) [Figure 6].

Osteonecrosis is seen as geographic areas of altered signal intensity of the patella with or without fragmentation [Figure 7].[3]

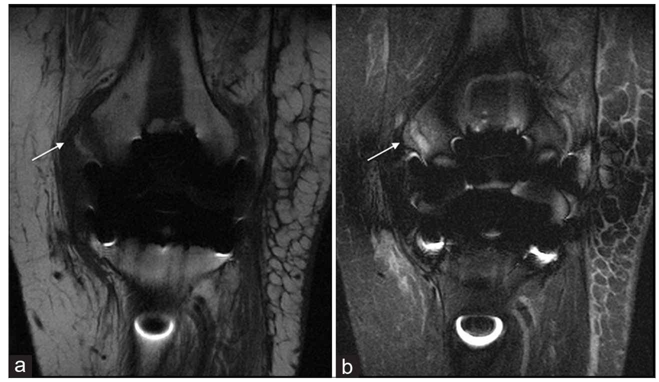

Figure 4: (a and b) Periprosthetic fracture: T1W (a) and STIR (b) coronal images showing fracture (arrow) at the femoral attachment of the medial collateral ligament with surrounding edema.

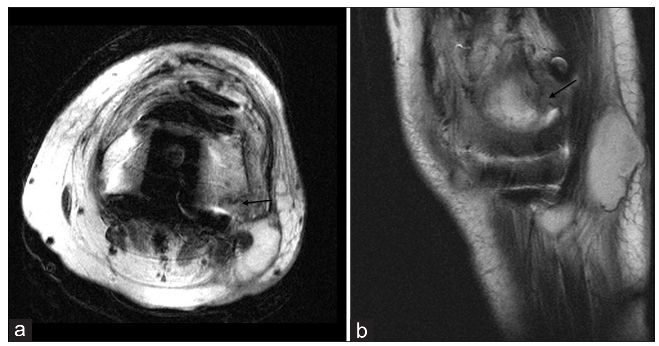

Figure 5: (a and b) Periprosthetic bone resorption: Axial (a) and sagittal (b) T2W images showing focal osteolysis (arrow) at the bone prosthesis interface of the lateral femoral condyle. An associated collection is also seen laterally.

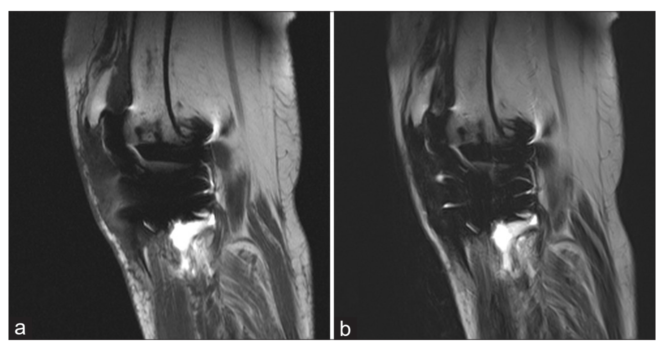

Figure 6: (a and b) Patella alta with patellar tendonitis: T1W (a) and T2W (b) sagittal images show a high riding patella with altered signal of the patellar tendon.

Patellofemoral osteoarthritis is seen as cartilage thinning/loss with subchondral marrow changes and osteophytes involving the patellar facets [Figure 8].

Impingement is suggested in cases with close approximation between the patella and femur and is usually associated with loss of patellofemoral joint space cartilage. Presence of a low signal soft tissue over the proximal patellar pole, the so-called patellar clunk syndrome was also suggestive of patellar impingement [Figure 9].[3]

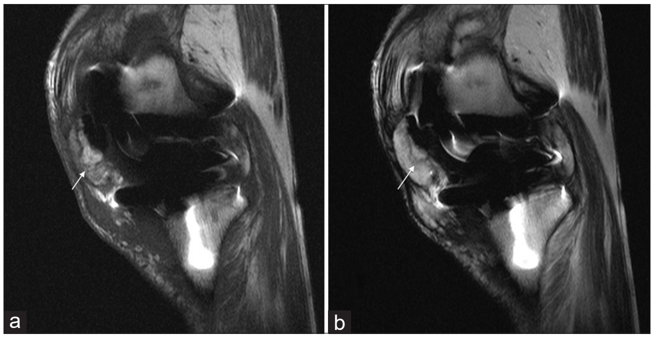

Figure 7: (a and b) Patellar osteonecrosis: T1W (a) and T2W (b) sagittal images showing geographical areas of altered signal intensity involving the patella (arrow).

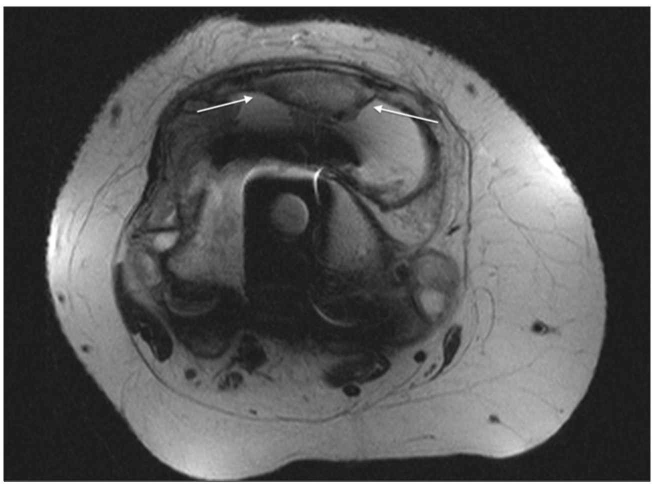

Figure 8: Patellofemoral osteoarthritis: Axial T2W image showing complete loss of the patellar facet cartilage (arrows).

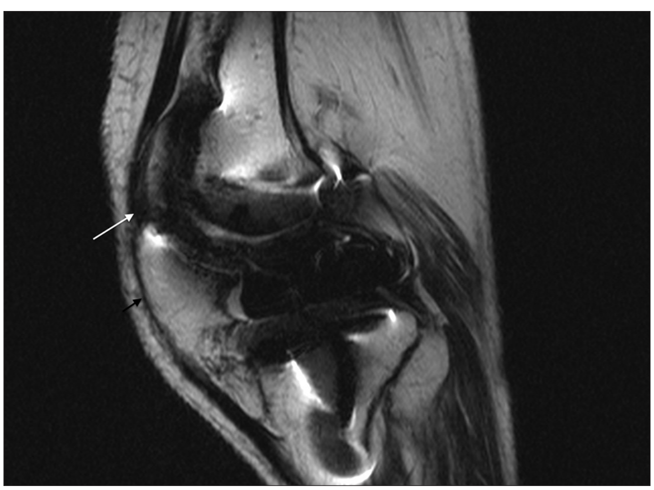

Figure 9: Patellar impingement: T2W sagittal images show a low lying patella (black arrow) with minimal predominantly low signal soft tissue at its proximal pole (white arrow). Patellar osteoarthritis with loss of patellar cartilage is also seen.

Patellar tendon tear is usually seen as a focal discontinuity or non-visualization of the tendon fibers. This is usually associated with patella alta due to proximal pull by the intact quadriceps tendon [Figure 10]. Diffuse altered signal of the tendon fibers is suggestive of tendinopathy if the signal is predominantly hyperintense on T2W images [Figure 6] and fibrosis if it is hypointense on T2W images. Patellar tendon fibrosis is usually associated with patella baja as it causes retraction and shortening of the tendon fibrils [Figure 11].

Bursitis is seen as distended inflamed fluid collections in expected locations around the knee. The inflammation can be either due to infection [Figure 12] or due to metal-induced reaction [Figure 13] or frictional. The metal-induced collections are often hyperintense on T1W images [Figure 13].

DISCUSSION

Diagnostic MR images can be easily obtained in patients with TKA using the MARS and are thus very helpful in elucidating

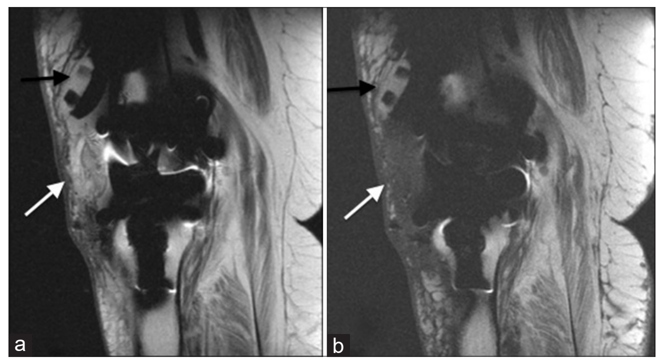

Figure 10: (a and b) Patellar tendon tear with patella alta: T1W (a) and T2W (b) sagittal images showing a high riding patella [black arrows] with non-visualization of patellar tendon (white arrows).

Figure 11: Patella baja with patellar tendon fibrosis: T2W sagittal images showing a low lying patella (long arrow) with thickened but otherwise intact patellar tendon (short arrow).

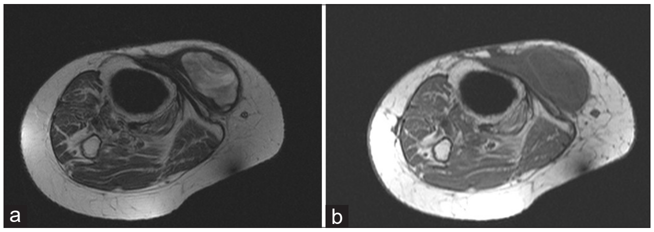

Figure 12: (a and b) Bursitis: T1W (a) and T2W (b) axial images showing a well-defined collection with T1 hyperintense rim in the region of the pes anserine bursa along the medial aspect of the proximal tibia.

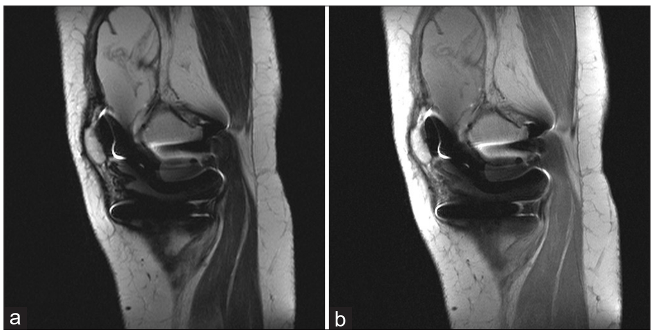

Figure 13: (a and b) Suprapatellar bursitis: T1W (a) and T2W (b) sagittal images show distended suprapatellar bursa with T1 hyperintense fluid.

the cause for patient's symptoms especially when the plain radiographs do not show any abnormality.

The abnormalities were found on MR in our patients included: Loosening (3), infection (7), osteolysis (2), and fracture (3), bursitis (4), and muscle tear/edema (2), ligament tears (3), complicated Baker's cyst (3), and other patellofemoral compartment abnormalities (9). Of these only seven patients had positive findings on radiographs which included patella alta (2), patella baja (2), lucency at the bone prosthesis interface (3), periprosthetic fracture (3), and loose bodies (1).

The patellofemoral compartment abnormalities identified included patellofemoral impingement/osteoarthritis (5), patellar tendonitis (5), patellar tendon tear (2), patellar osteomyelitis (1), patellar osteonecrosis (1), patella alta (2), patella baja (2), and loosening of the patellar button (1).

The most common cause of symptoms in patients with TKR was periprosthetic infection. However, no feature suggestive of infection was seen in any of the knees on plain radiographs. Bursitis, muscle edema/tear, patellar tendonitis/tear, patellar osteonecrosis, medial collateral ligament tears, and Baker's cyst were also diagnosed solely with MR with no suspicion of these on the corresponding radiographs. Loosening and fractures were, however, picked up equally on both MR and radiographs.

None of the patients studied showed evidence of non-infective bone resorption/focal particle disease.

CONCLUSION

With the ever-increasing number of TKAs worldwide, the demand for prompt and early diagnosis of the causes of post arthroplasty knee pain has increased as well.

Radiographs and nuclear imaging, earlier the mainstays for evaluation of the post-TKA knee[4] have limitations especially with respect to evaluation of the soft tissue abnormalities, which account for symptoms in a significant number of patients. MR, with its specialized MARS, has proven to be of immense help in the detailed evaluation of these soft tissue complications.[10]

MR allows early diagnosis of infection before changes are evident on radiographs and thus allows prompt and early treatment.[3]

Patellar tendon and ligamentous abnormalities easily seen on MR were not visible on the radiographs. Patellofemoral osteoarthritis, unless in advanced stages was also not seen on the radiographs. Arthrofibrosis and bursitis clearly evident on MR were also not diagnosed on radiographs in most of the cases. Lymph nodes can be seen clearly as well and give a clue to the presence of long-standing inflammation or acute/chronic infection.

MR also is more sensitive in diagnosing stress fractures. Differentiating between periprosthetic osteolysis and osteopenia that occur in areas of decreased stress ("stress shielding"), is also quite straightforward with MR.[10]

This study thus underlines the potential MR has in the prompt and early diagnosis of complications in patients with total knee arthroplasties. It also describes the imaging appearance of the various complications.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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