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SCIENTIFIC ARTICLE

MRI findings in bipartite patella

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Abstract
Purpose Bipartite patella is a known cause of anterior knee pain. Our purpose was to detail the magnetic resonance imaging (MRI) features of bipartite patella in a retrospective cohort of patients imaged at our institution.
Materials and methods MRI exams from 53 patients with findings of bipartite patella were evaluated to assess for the presence of bone marrow edema within the bipartite fragment and for the presence of abnormal signal across the synchondrosis or pseudarthrosis. Any other significant knee pathology seen at MRI was also recorded. We also reviewed 400 consecutive knee MRI studies to determine the MRI prevalence of bipartite patella.
Results Of the 53 patients with bipartite patella 40 (75%) were male; 35 (66%) had edema within the bipartite fragment. Of the 18 with no edema an alternative explanation for knee pain was found in 13 (72%). Edema within the bipartite fragment was the sole finding in 26 of 53 (49%) patients. Bipartite patella was seen in 3 (0.7%) of 400 patients.
Conclusion In patients with bipartite patella at knee MRI, bone marrow edema within the bipartite fragment was the sole finding on knee MRI in almost half of the patients in our series.

Keywords Bipartite · Patella · MRI

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Introduction

Bipartite patella is a developmental variation in which peripheral, accessory ossification centers fail to fuse with the main body of the patella. Painful bipartite patella is a known cause of anterior knee pain [1]. Plain film radiography and bone scintigraphy have been used in the diagnosis of this condition [2]. There are very few reports regarding the magnetic resonance imaging (MRI) appearances of bipartite patella in the English language literature, with no large series yet described. Our purpose was to detail the MRI features of bipartite patella in a retrospective cohort of 53 patients presenting to our institution for knee MRI.

Materials and methods

After creating a study design protocol, this retrospective study was carried out in compliance with Health Insurance Portability and Accountability Act (HIPAA) regulations and with approval by our Institutional Review Board (IRB). A waiver of informed consent was granted by our IRB.

From a database of 27,944 knee MRI examinations acquired at our institution from January 2000 through March 2006, a report database search was performed for the terms “bipartite” and “bipartite patella.” This search yielded

54 cases of a segmented patella which were available for retrospective review. Bipartite patella was defined as a visible fragmentation of the bony patella in one of the typical reported locations [3], with at least two ossific segments and no MRI findings of fracture or direct trauma. One case was excluded when it was determined that the findings were typical for a traumatic patellar fracture. The remaining 53 subjects constituted our study group.

All patients were imaged using a standard knee protocol at either 1.5 (n=48) or 0.7 T (n=5). The following sequences were utilized at 1.5 T: sagittal proton density fast spin echo (FSE), field of view (FOV): 14–16 cm, matrix: 512×256, number of excitations (Nex): 2, slice thickness: 4 mm, time to repetition (TR): 3,000, time to echo (TE): 25, echo train length (ETL): 4, bandwidth (BW): 16; sagittal T2 FSE with fat saturation, FOV: 14–16 cm, matrix: 256×256, Nex: 2, slice thickness: 4 mm, TR: > 2,000, TE: 50–60, ETL: 8, BW: 16; coronal T1 spin echo, FOV: 16–18 cm, matrix: 256×192, Nex: 1, slice thickness: 3 mm, TR: 400–800, TE: minimal, BW: 16; coronal T2 FSE with fat saturation, FOV: 16–18 cm, matrix: 256×256, Nex: 2, slice thickness: 3 mm, TR: >2,000, TE: 50–60, ETL: 8, BW: 16; axial T2 FSE with fat saturation, FOV: 14–16 cm, matrix: 256×256, Nex: 2, slice thickness: 3 mm, TR: >2,000, TE: 50–60, ETL: 8, BW: 16. The following sequences were utilized at 0.7 T: sagittal proton density FSE, FOV: 18 cm, matrix: 256×256, Nex: 2, slice thickness: 4 mm, TR: 2,700, TE: 30, ETL: 4, BW: 16; sagittal T2 FSE with fat saturation, FOV: 18 cm, matrix: 256×256, Nex: 2, slice thickness: 4 mm, TR: >2,000, TE: 50–60, ETL: 8, BW: 16; coronal T1 spin echo, FOV: 20 cm, matrix: 256×192, Nex: 1, slice thickness: 3 mm, TR: 400–800, TE: minimal, BW: 16; coronal T2 FSE with fat saturation, FOV: 18 cm, matrix: 256×256, Nex: 2, slice thickness: 3 mm, TR: >2,000, TE: 50–60, ETL: 8, BW: 16; axial T2 FSE with fat saturation, FOV: 14–16 cm, matrix: 256×256, Nex: 2, slice thickness: 3 mm, TR: >2,000, TE: 50–60, ETL: 8, BW: 16.

Bone marrow edema was defined as increased signal on T2-weighted FSE, fat-saturated sequences with accompanying decreased signal on T1-weighted spin echo sequences when compared with the bone marrow signal in the mid-body of the patella, and in the mid-femoral condyles. Cartilage signal within the synchondrosis was defined as signal intensity on fat-suppressed, fluid-sensitive, and T1-weighted sequences similar to the signal intensity at the articular cartilage at the patellar undersurface. Fibrous signal was defined as signal intensity hypointense to bone marrow and articular cartilage on T1-weighted and fat-suppressed, fluid-sensitive sequences. Fluid signal was defined as signal intensity on T2-weighted FSE fat-saturated, fluid-sensitive, and T1-weighted sequences similar to joint fluid.

Cases were evaluated to assess for the presence of bone marrow edema within the bipartite fragment and for the presence of abnormal signal across the synchondrosis or pseudarthrosis. Other significant knee pathology including meniscal tears, ligament tears, osteoarthritis, and extensor mechanism injuries by MRI were also recorded. Examinations were reviewed by two musculoskeletal radiologists by consensus.

We then performed a second computer search of our MRI reports database for the most recent consecutive 400 MRI knee cases for all indications. These cases were then evaluated by two musculoskeletal radiologists in consensus prospectively to determine the MR prevalence of bipartite patella within this separate group.

Results

All patients in our study group had symptoms of knee pain as noted in the history section of the radiology reports. Of these 53 patients with MRI findings of bipartite patella, 40 (76%) were male and 13 (24%) were female. The mean age of the entire study group was 38 years (range: 13–68 years).

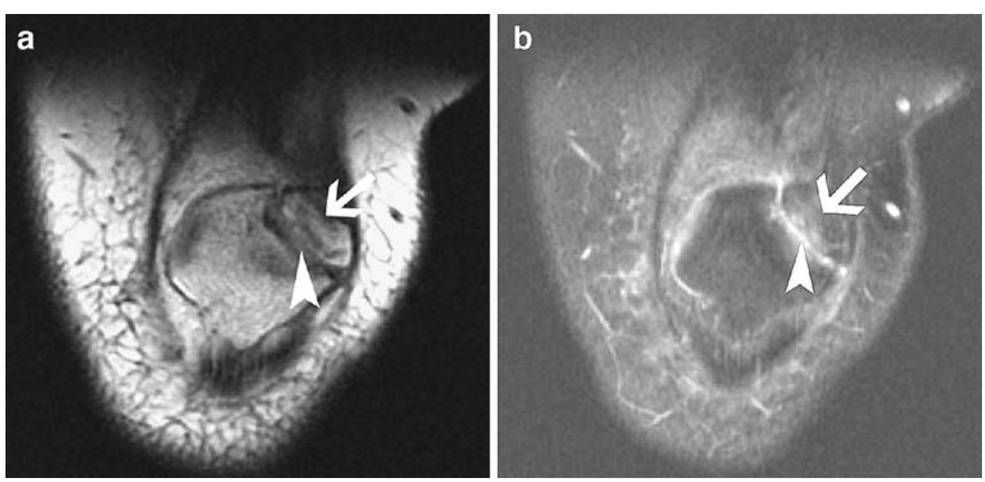

Fig. 1 A 30-year-old female patient with knee pain and bipartite patella. **a** Coronal T1-weighted MR image confirms the presence of a bipartite fragment at the superolateral pole of the patella (*arrow*). Also note the cartilage signal across the synchondrosis (*arrowhead*). **b** Coronal T2-weighted image with fat saturation shows the presence of bone marrow edema within the bipartite fragment (*arrow*) and confirms the presence of cartilage signal across the synchondrosis (*arrowhead*)

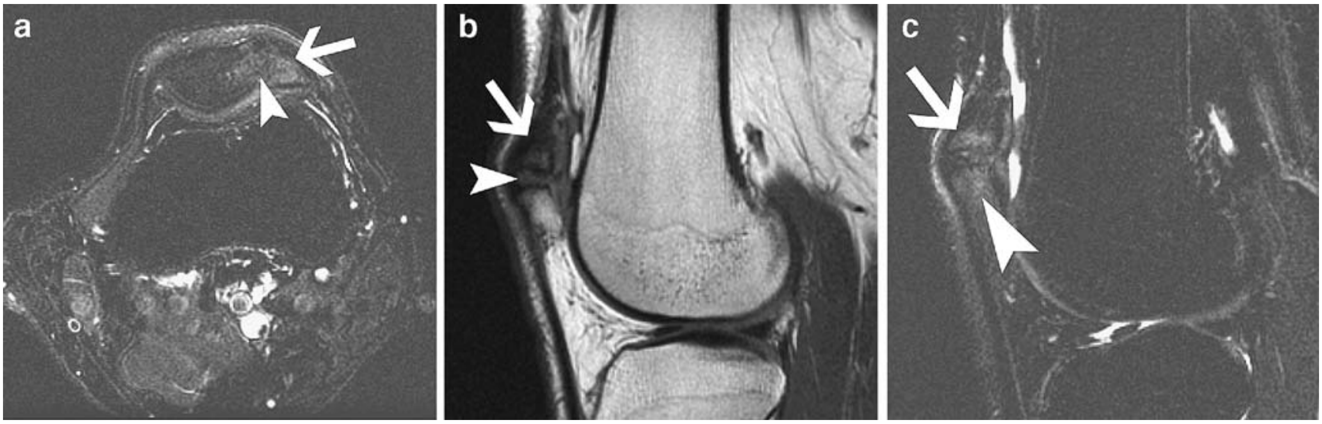

Fig. 2 An 18-year-old male patient with knee pain and bipartite patella. **a** Axial T2-weighted image with fat saturation shows a bipartite patella with internal bone marrow edema (*arrow*). Note the presence of cartilage signal across the synchondrosis (*arrowhead*). **b** Sagittal T1-weighted image shows the bipartite fragment (*arrow*), with cartilage signal across the synchondrosis (*arrowhead*). **c** Sagittal T2-weighted image with fat saturation shows bone marrow edema within the bipartite patella (*arrow*) and within the patella adjacent to the synchondrosis (*arrowhead*)

All of the bipartite fragments were located at the superolateral quadrant of the patella. Thirty-five patients (66%) had edema within the superolateral bipartite fragment. Three of these patients were imaged at 0.7 T, with the remaining 32 imaged at 1.5 T. Edema within the superolateral bipartite fragment was the sole abnormal MRI finding in 26 of 53 (49%) patients (mean age: 35 years, range: 13–68 years). Nine patients (mean age: 37 years, range: 22–50 years) had edema within the superolateral bipartite fragment as well as other significant pathology including one patient with an anterior cruciate ligament tear, one with a complete quadriceps tendon tear, two with quadriceps tendinosis, and five patients with advanced patellofemoral osteoarthritis. Of the 18 patients with no edema within the bipartite fragment, an alternative explanation for knee pain was found in 13 (72%) patients (mean age: 41 years, range: 18–69). Diagnoses in these 13 patients included 3 with MRI findings of patellar tracking abnormalities [4], 3 with meniscal tears, 1 jumper's knee, 2 patients with quadriceps tendinosis, and 4 patients with advanced patellofemoral osteoarthritis. Of 53 patients, 28 (53%) demonstrated T1 and T2 signal across the segmentation between the patella and its superolateral bipartite fragment typical for normal hyaline cartilage and a synchondrosis (Figs. 1, 2, and 3). Nineteen patients (36%) demonstrated low T1 and T2 signal across the segmentation typical for a fibrous coalition (Fig. 4). Six patients (11%) demonstrated fluid bright signal across the segmentation typical for a pseudoarthrosis (Fig. 5). Of the 35 patients with edema within their superolateral bipartite fragment, 20

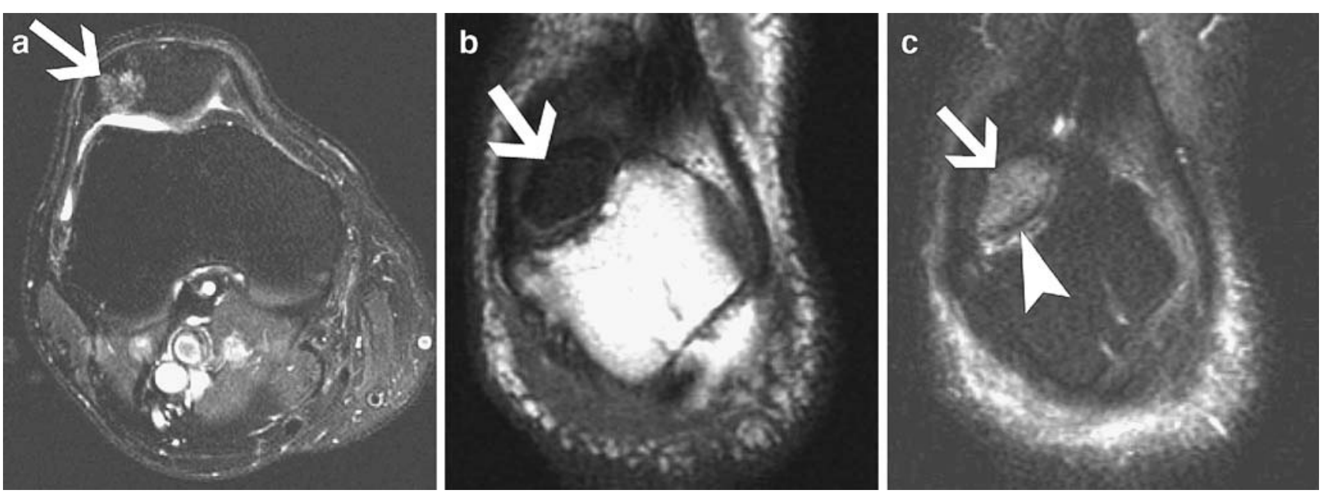

Fig. 3 A 63-year-old male patient with knee pain and bipartite patella. **a** Axial T2-weighted image with fat saturation shows a bipartite patella with internal bone marrow edema (*arrow*). **b** Coronal T1-weighted image shows extensive T1 hypointensity abnormality within the bipartite fragment (*arrow*). **c** Coronal T2-weighted image with fat saturation shows extensive bone marrow edema within the bipartite patella (*arrow*) and cartilage signal across the synchondrosis (*arrowhead*)

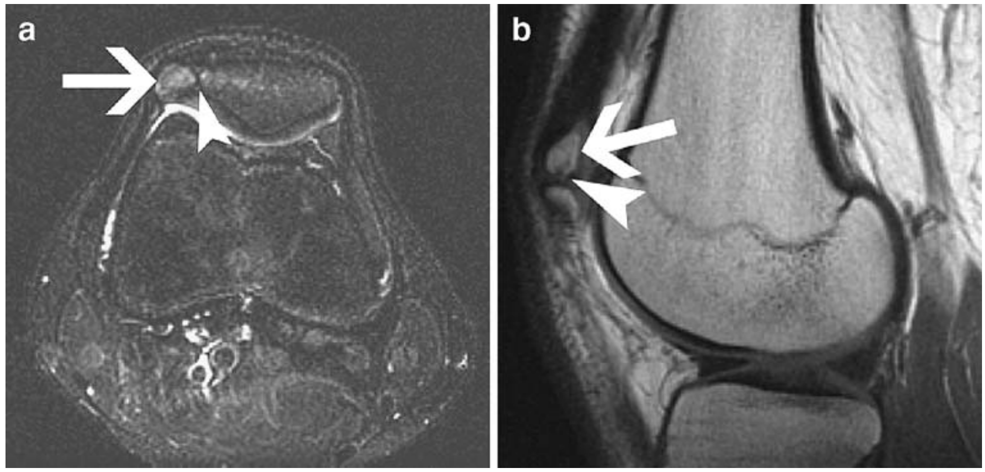

Fig. 4 A 25-year-old male patient with knee pain and bipartite patella. **a** Axial T2-weighted image with fat saturation shows the presence of a bipartite patella with internal edema (*arrow*). Note the presence of fibrous union present between the patella and its bipartite fragment (*arrowhead*). **b** Sagittal T1-weighted image confirms the presence of a bipartite patella (*arrow*) and also shows the fibrous union between the patella and its bipartite fragment (*arrowhead*)

(57%) had cartilage signal, 5 (14%) had fluid signal, and 10 (29%) patients had fibrous signal across the segmentation. Of the 18 patients without edema within their bipartite fragment, 8 (44%) had cartilage signal, 1 (6%) had fluid signal, and 9 (50%) patients had fibrous signal across the segmentation. In the prospective arm of our study, bipartite patella was seen in 3 (0.7%) of 400 patients.

Discussion

Bipartite patella is a developmental anomaly which is usually regarded as a variant of normal ossification. The patella begins as a cartilaginous structure that begins to ossify between 3 and 5 years of age. Ossification proceeds from central to peripheral until the age of 6. Ogden describes the development of accessory ossification centers especially at the superolateral quadrant that generally fuse with the main ossification center by age 12 as a developmental variant [3]. While at least three different locations of bipartite patella have been described, it typically involves the superolateral aspect of the patella, at the insertion of the vastus lateralis muscle, is seen in approximately 2% of the population, and is almost always bilateral. Bipartite patella is more common in males than females by a ratio of 9:1.

Many cases of bipartite patella are asymptomatic and the anomaly is frequently discovered incidentally. Recognizing that a bipartite patella is a normal variant, its role as a potential cause of knee pain can be overlooked during MRI interpretation. Indeed, unless a fat-suppressed image is acquired, local edema at the site and along the margins of the synchondrosis or pseudarthrosis may not be identified and its role in the generation of knee pain might not be recognized. The results of this study, combining clinical and MR imaging features, suggest that bipartite patella is a more frequent cause of knee pain than was previously recognized. Rather than discounting the entity as being a

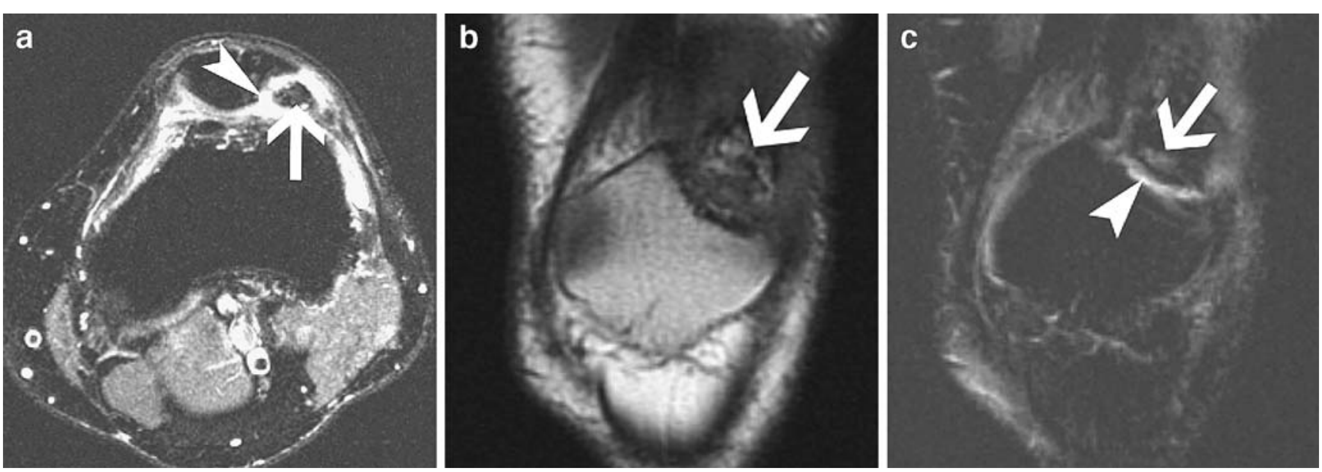

Fig. 5 A 41-year-old male patient with knee pain and bipartite patella. **a** Axial T2-weighted image with fat saturation shows a bipartite patella (*arrow*), with fluid bright signal between it and the patella (*arrowhead*), typical for a pseudarthrosis. **b** Coronal T1-weighted image confirms the presence of a bipartite patella (*arrow*), with internal signal abnormality. **c** Coronal T2-weighted image with fat saturation shows edema within the bipartite fragment (*arrow*) and confirms the presence of fluid bright signal, or a pseudarthrosis, between the bipartite patella and the remainder of the patella (*arrowhead*)

normal variant, a detailed search should be undertaken for signs of edema both within the bipartite fragment and along the margins of the synchondrosis or pseudarthrosis, especially in patients presenting with anterior knee pain.

The natural history of bipartite patella is not yet fully understood, but it has been observed that the two patellar fragments may proceed to fusion in the second decade. Although in most patients the morphologically segmented patella remains asymptomatic and the associated articular cartilage remains intact, occasionally, perhaps more frequently than previously recognized, in response to overuse or acute injury, a synchondrosis may become either partly or completely disrupted, allowing abnormal motion, friction, and subsequently the development of edema. We theorize that this course of events may manifest as fluid signal between the patellar body and bipartite fragment, or a pseudarthrosis. Less frequently, excessive motion may lead to impaction of the bipartite fragment and the development of bone edema (35 of 53 patients in this study) within the fragment either due to trabecular injury or secondary ischemia, presenting as localized pain.

One previous study described nine patients with painful bipartite patella following direct macrotrauma, and each of these patients had a delayed presentation at a mean of 2 years following injury, because of failure to recognize the described phenomenon of symptomatic bipartite patella [5]. Other authors have described acute fracture of the bipartite patella fragment following direct trauma [6, 7]. This paper presents a group of patients without a history of direct trauma, in whom the bipartite fragment appears to have become symptomatic as a result of overuse and secondary abnormal patellofemoral tracking. It is postulated that repeated knee flexion and extension, with traction from the lateral retinaculum and vastus lateralis, generates abnormal stress on the synchondrosis and the lateral bipartite fragment, with incurred altered tracking manifest bone marrow edema.

Although radiographs and computed tomography allow identification of the bipartite fragment, they do not allow for the identification of bone marrow or soft tissue edema. As an alternative to MRI, several authors have described the use of scintigraphy in this role [2], but this technique is limited by its low specificity. In effect, MRI is likely to be the most appropriate method of assessing this patient group.

Following diagnosis, many patients are managed conservatively, combining the use of nonsteroidal anti-inflammatories with remobilizing physical therapy. Occasionally physical therapy is supplemented successfully by the use of patellar strapping. Less frequently surgery is undertaken, ranging from a lateral retinacular release in an effort to improve patellofemoral tracking, through definitive resection of the patellar fragment, and subsequent tendinous reattachment [8].

Finally, previous authors have reported a 2–3% prevalence by radiography, which is greater than the 0.7% prevalence generated by our prospective review of 400 knee MRI studies. The lower prevalence in our study is unexplained but may reflect population bias in either group. We had also expected to find more cases of bipartite patella in our initial computer search of 27,944 knee MRI reports. We searched for the terms “bipartite” and “bipartite patella” in our computer search. It is conceivable that some cases of bipartite patella were not noted at MRI, but as these studies were not individually viewed it is difficult to explain the lower than expected number of cases. This is the reason why we chose to assess the prevalence of bipartite patella by prospectively reviewing 400 knee MRI studies. In a review of surgical literature, Insall reported that the prevalence of bipartite patella at surgery was 0.2–5% [9], which is closer to the findings reported in this series.

There are a number of limitations to our study; first, this is primarily a retrospective study design and the number of cases in the study group is relatively small. Second, this retrospective series does not include a control group for knee pain, which limits any conclusions that can be made with regards to symptoms that may be secondary to bipartite patella. Additionally the exact location of knee pain was not recorded on our radiology reports. Also, we were not able to access adequate clinical follow-up of these patients to determine the likelihood of the bipartite patella being the primary cause of knee symptomatology, which is another relative limitation of this study. This is, however, the largest group reported of patients with bipartite patella imaged with MRI.

In summary, this study outlines the role of knee MRI in the evaluation of bipartite patella. Bone marrow edema within the bipartite fragment was the sole imaging finding in almost 50% of our patients. In patients presenting with anterior knee pain, and without other MRI findings, we suggest that identification of edema at or adjacent to the bipartite fragment by MRI may reflect a scenario where the bipartite patella is the primary cause of symptomatology. Thus, MRI plays an important role in the evaluation of patients with bipartite patella and knee pain. In our prospective group of 400 patients having knee MRI examinations, the prevalence of bipartite patella was less common than has been previously reported.

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