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SCIENTIFIC ARTICLE

Increased signal in the proximal patellar tendon: normal or pathologic?

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Abstract

Objective To determine the clinical significance of T2 signal hyperintensity in the proximal patellar tendon seen on MRI of the knee.

Materials and methods MRIs of 100 patients who underwent MRI of the knee between 1 May 2018 and 15 July 2018 were retrospectively evaluated. All examinations were performed on 3-Tesla MRI scanners with a dedicated knee coil and in accordance with our institution's standard knee MRI protocol. The presence of increased T2 signal was assessed on both sagittal and axial T2-weighted fat-saturated images. The amount of increased signal in the proximal patellar tendon on T2-weighted images was characterized as: none, mild, moderate, or severe. A corresponding chart review of the referring physicians' notes was performed to determine the presence of clinical symptoms of patellar tendinopathy. Patellar tendinopathy was considered present if the clinical notes described tenderness on palpation of the inferior patellar pole, infrapatellar tenderness, or patellar tendinosis/tendinitis.

Results The majority (66%) of knee MRIs demonstrated the presence of increased T2 signal in the proximal patellar tendon. Only 4.5% of these patients had associated clinical findings of patellar tendinopathy.

Conclusion Although increased T2 signal in the proximal patellar tendon is a common finding, only in rare cases are there associated clinical symptoms. Thus, increased T2 signal in the proximal patellar tendon may not be a pathological finding in the absence of clinical findings of patellar tendinopathy.

Keywords Patellar tendon · MRI · Knee

Introduction

Determining whether abnormal imaging findings are incidental or pathological can be particularly challenging for the radiologist; moreover, this task has been complicated by the development of increasingly sensitive imaging techniques. The utility of MRI in the evaluation of the soft-tissue structures of the knee is incontrovertible, and with improvements in MRI technology and surface coils, the accuracy of MRI continues to increase [1, 2]. Numerous studies have identified increased T2 signal in the deep fibers of the proximal patellar tendon on MRI [3–9]. There is some controversy as to whether this finding is a normal variant or a reliable indicator of patellar tendon pathology. Although a number of studies have looked at cohorts of patients with patellar tendinopathy and determined a positive correlation with intrasubstance signal [3–5], fewer studies have examined the incidence of increased signal in asymptomatic patients [6, 7, 10–12].

Our study is aimed at determining the clinical significance of T2 signal hyperintensity in the proximal patellar tendon seen on MRI of the knee: specifically, we aim to determine whether this finding alone is indicative of patellar tendon pathology or whether it should be viewed as a normal variant in the absence of clinical signs and symptoms of patellar tendinopathy.

Lyndsey Burton's work on this paper was done while at UCLA Department of Radiology.

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Materials and methods

Internal review board exemption was obtained for this study. Using our institution's tool for searching radiology reports (MONTAGE™ Search and Analytics), a search was performed for knee MRIs without contrast medium administration performed between 1 May 2018 and 15 July 2018. MRI requisitions providing "knee pain" as the indication were included in the study. Patients younger than 18 years of age were excluded. This search yielded 358 reports from all our institution's imaging centers. Thirteen of these patients had a history of trauma and were excluded. We then performed a random review of these patients and their charts, excluding those who lacked clinical notes with physical examination findings documented within 2 weeks of the knee MRI examination. In our initial study design, we planned to review 100 knee MRIs; thus, we stopped our review when we had reviewed 100 MRIs and patient charts that satisfied our inclusion criteria. All MRIs were performed at our institution on 3-Tesla devices, made by either Siemens or General Electric, with the use of a dedicated knee coil. Studies were performed in accordance with our institution's standard knee MRI protocol. MRI parameters for T2-weighted fat-saturated sequences included echo time of 53 ms, image matrix of 307 × 384, echo train length of 13 ms, and receiver bandwidth of 200 Hz per pixel. Patients ranged in age between 18 and 74, with an average age of 40.8 years, median age of 39.5, and a standard deviation of 15.7. Of the patients, 47 were male and 53 were female. There was no statistically significant difference in the average age of the male and female subjects. The average age of women was 40.5 years, median age 39 years, with a standard deviation of 17.1. The average age of men was 41.0 years, median age 42, with a standard deviation of 14.1.

The presence of increased T2 signal in the proximal portion of the patellar tendon was assessed on both sagittal and axial T2-weighted fat-saturated images. Images were evaluated by a single individual. When increased signal was identified, it was seen in the deep fibers of the tendon from the insertion of the tendon on the inferior patella and extending inferiorly. It was ascertained that this increased signal was not due to a sagittal cut through a striated area, but was a true finding on multiple consecutive sagittal cuts. The width of increased signal was measured on sagittal T2-weighted images. The ratio of increased signal antero-posterior width to antero-posterior width of the patellar tendon at the same level was calculated (Fig. 1) to the hundredth decimal place. The signal was graded as: none (0 < 0.10), mild (0.10–0.24), moderate (0.25–0.74), and severe (0.75–1.0), with none corresponding to a uniformly black tendon on T2-weighted images (Figs. 2, 3). Subsequently, a review of the patient's previous clinic visit note was performed to assess for the presence of clinical symptoms of patellar tendinopathy. Patellar tendinopathy was considered present if the clinical notes described any of the following: infrapatellar tenderness, tenderness to palpation of the inferior patellar pole, or a clinical diagnosis of patellar tendinopathy [9, 13].

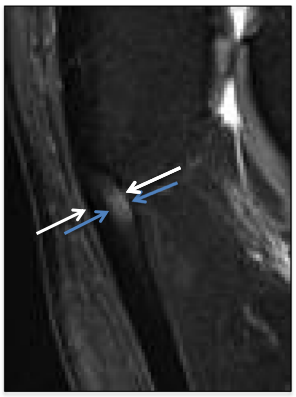

Fig. 1 Sagittal T2-weighted MR image demonstrating our method of measurement of the width of increased T2 signal. The white arrows show the antero-posterior width of the proximal patellar tendon, and the blue arrows show the antero-posterior width of increased T2 signal in the deep fibers of the proximal patellar tendon. We measured these widths on all knees and determined the ratio (blue line/white line). This is a knee MRI from a 55-year-old woman with no clinical symptoms of patellar tendinopathy

Results

Out of 100 MRIs of the knee, 66 (66%) demonstrated the presence of T2 signal hyperintensity in the deep fibers of the proximal patellar tendon and 34 (34%) demonstrated no T2 signal hyperintensity. Of the 66 patients with T2 signal hyperintensity, 15 demonstrated mild signal, 48 demonstrated moderate signal, and 3 demonstrated severe signal. Only 3 (4.5%) of these 66 patients presented with clinical signs or symptoms compatible with patellar tendinopathy (Table 1). One of these patients had a mild amount of T2 signal hyperintensity, and two of these patients had a moderate amount of T2 signal hyperintensity in the deep proximal patellar tendon fibers. None of the patients with severe T2 signal hyperintensity had clinical signs or symptoms of patellar tendinopathy. Of the 34 knee MRIs with no increased T2 signal in the patellar tendon, one of the patients had clinical notes documenting findings of patellar tendinosis (2.9%).

Discussion

Patellar tendinopathy is a common condition affecting the patellar tendon; the condition is particularly prevalent among athletes who participate in sports involving forced contraction

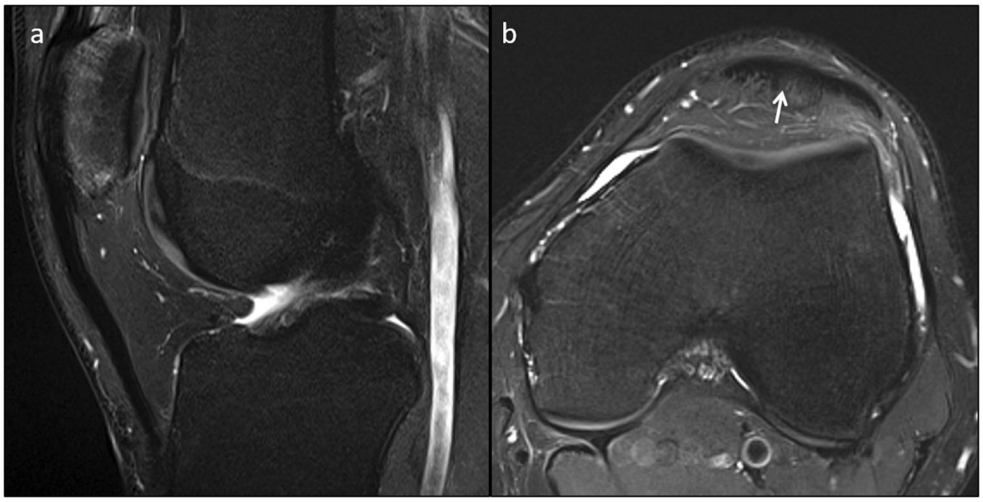

Fig. 2 **a** Sagittal and **b** axial T2-weighted fat-saturated MR images of the knee demonstrating the normal appearance of a black patellar tendon. No increased T2 signal is present within the patellar tendon on either image. Normal striations are visualized (arrow). These images are from a knee MRI of a 19-year-old man with no clinical signs or symptoms of patellar tendinopathy

of the quadriceps muscle, i.e., in jumping, such as basketball and volleyball [9, 13]. Clinical signs include localized pain and tenderness [8, 14]. Mild forms of this condition are generally treated conservatively, with rest, cessation of the offending activity if there is one, and anti-inflammatory drugs [5]. Severe forms of the condition may be treated surgically.

The normal appearance of the patellar tendon on MRI is that of a structure of homogeneous low signal intensity on all sequences [9, 15]. Findings on MRI of patellar tendinopathy include tendon thickening and focal areas of high T2 signal. Multiple studies have demonstrated nearly consistent findings of focal areas of high T2 signal in the proximal patellar tendon in patients with known patellar tendinosis [3–5, 8, 9]. However, there is some controversy as to the utility of these findings on MRI without the corresponding clinical symptoms.

Various cohorts of professional and nonprofessional athletes have been studied, and multiple studies have demonstrated MRI evidence of patellar tendinopathy in these patient populations with no clinical symptoms [6, 7, 9–12]. Schmid et al. found increased signal within the proximal patellar tendon in 18 out of 19 symptomatic knees and in 23 out of 32 asymptomatic knees [13]. Major and Helms found a 24% incidence of increased signal in the patellar tendon in asymptomatic college basketball players [7], and Walczak et al. found a 39.3% prevalence of increased proximal patellar signal in the knees of professional basketball players [16]. Pappas et al. also looked at asymptomatic college basketball players and found increased signal in 83% of preseason knees and 90% of postseason knees [11]. Reiff et al. examined patellar tendon signal on gradient echo imaging in 60 patients without symptoms related to the anterior knee and found that 75% of these patients had focally increased signal in the proximal patellar tendon; they concluded that increased signal was within the normal range [12].

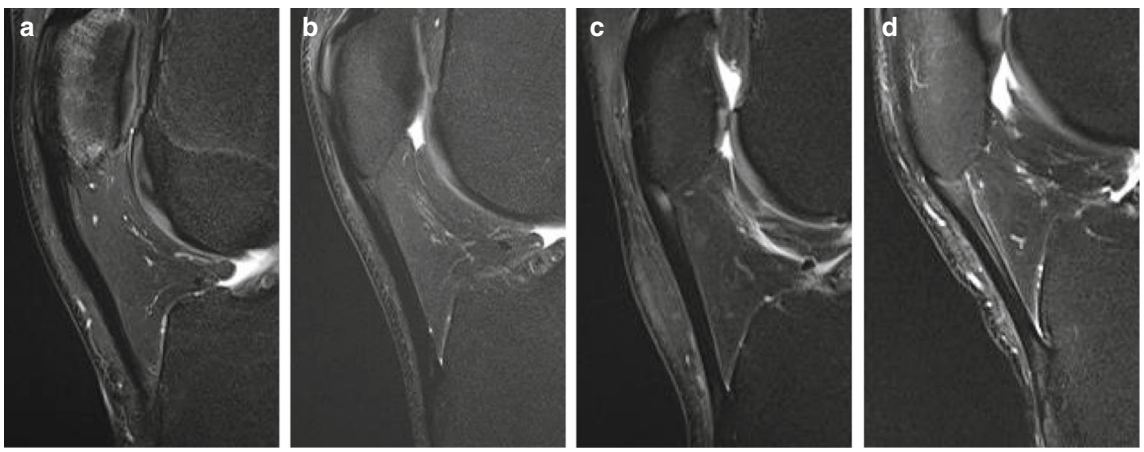

Fig. 3 Sagittal T2-weighted MR images demonstrating **a** none, **b** mild, **c** moderate, and **d** severe amounts of increased T2 signal in the deep fibers of the proximal patellar tendon. The patients are as follows: **a** a 19 year-old male, **b** a 31 year-old male, **c** a 55 year-old female, and **d** a 33 year-old male. None of these patients had symptoms of patellar tendinopathy

Table 1 Description of associations between signal intensity and clinical symptoms

		Clinical symptoms		Totals
		No symptoms	Yes symptoms	
Signal intensity	No signal	33	1	34
	Mild signal	14	1	15
	Moderate signal	46	2	48
	Severe signal	3	0	3
	Totals	96	4	100

Potential causes of nonpathologically increased signal in the patellar tendon have been proposed. Yun et al. examined cadaver tendons on MRI and then histologically—they found that signal changes on MRI corresponded to areas of invaginated adipose tissue, vessels, and perivascular connective tissue [17].

In our study, we found that of the patients with increased T2 signal, 4.5% demonstrated clinical symptoms of patellar tendinopathy. Of the patients without increased T2 signal, 2.9% demonstrated clinical symptoms, a difference of 1.6%. Our small study sample size does not permit precision due to the low power of the study. Further research is needed to determine the general application of our results.

A potential pitfall in the evaluation of increased signal on MRI is the magic angle phenomenon. This phenomenon occurs in structures with tightly bound collagen fibers (such as tendons) and is related to dipolar interactions within these structures. An in-depth discussion of this phenomenon is beyond the scope of this paper, but the phenomenon depends on the orientation of the collagen fibers to the static magnetic field [18, 19]. A falsely increased signal intensity is seen when the angle between these fibers and the magnetic field is 54.7°. The magic angle phenomenon is described in short echo time sequences, such as T1- and proton density-weighted. In our study, we evaluated the appearance of the patellar tendon on T2-weighted images; thus, it is unlikely that the magic angle phenomenon played a role in the increased signal that we saw. Other studies, such as Schmid et al., found increased signal in the patellar tendon on both T2- and T2*-weighted images [13]. In their study, the examinations were performed with the patellar tendons perpendicular to the main magnetic field; thus, they concluded that this increased signal was not due to magic angle artifact [13]. Yun et al. also saw increased signal in the patellar tendon on all sequences, not just those with short TE, also concluding that the increase in signal was not due to the magic angle phenomenon [17].

We note that a limitation of our study was the use of clinical assessment as the standard of reference. The patients in our cohort were not all examined by the same physicians, and we had no way of standardizing the physical examination portion of our study.

In summary, there is a high incidence of increased signal within the proximal patellar tendon without any associated clinical findings of pathology [4, 5, 8, 20]. Our study, when combined with multiple previous studies, highlights the importance of clinical correlation and calls for caution in identifying increased signal in the proximal patellar tendon as pathologic.

Compliance with ethical standards

Conflicts of interest The authors declare that they have no conflicts of interest.

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