https://doi.org/10.15218/zjms.2022.017

Evaluation of anterior knee pain by MRI in Erbil city, Iraqi Kurdistan Region

Received: 09/02/2021 Accepted: 08/12/2021

Haveen Azo Mohammad Amien[1]*

Abstract

Background and objective: Anterior knee pain is a common reason for consultation due to knee pathology among teenagers and young adults. Knowledge of the radiological appearance of the abnormalities allows a more accurate diagnosis of the cause of the pain. This study aimed to determine the causes of anterior knee pain and assess the role of MRI in evaluating cases of anterior knee pain and achieving accurate diagnosis and grading of some of the most common pathologies.

Methods: This cross-sectional study included 115 patients suffering from knee joint pain, referred to the radiology department, Rizgari Teaching Hospital from the rheumatology or orthopedic outpatient clinics, or private clinics between March 2017 and January 2020. Only 34 patients had anterior knee pain. All patients underwent an MRI examination.

Results: MRI examination was carried out for 34 knees of 115 patients with anterior knee pain, including 13 males (38.24%) and 21 females (61.76%). The mean age of the patients was 31 years (range 14-52 years). Most of the cases presented clinically with AKP, and four cases presented with a history of pain after trauma. Twelve cases (35.29%) had patella Alta while two cases (5.8%) had patella Baja. Trochlear dysplasia was reported in seven cases (20.58%), and type C was the most common trochlear dysplasia, which was seen in four cases out of seven (57.14%). Patellar maltracking was seen in eightcases (23.52 %), tilt of the patella in 10 cases (29.41%), and a combination of patellar tilt, Alta, and maltracking was seen in eight cases (23.52%). Six cases (17.64%) showed a combination between trochlear dysplasia, patellar tilt, and maltracking. Thirty one patients (91.17%) showed signs of patellofemoral arthrosis, and joint effusion was seen in 30 patients (88.23%). Suprapatellarplica was seen in two cases (5.40%).

Conclusion: The most common cause of anterior knee pain is patellofemoral instability, either due to abnormal morphology /or joint geometry or post-traumatic, and it is occasionally caused by a serious underlying systemic disease, including inflammatory conditions and malignancies. MRI offers superior soft tissue contrast resolution and allows a more accurate evaluation of the underlying etiology.

Keywords: Knee joint; Pain; MRI; Evaluation.

Introduction

Anterior knee pain (AKP) is one of the most common reasons for consultation due to knee pathology among teenagers and young adults.[1] Knowledge of the radiologic appearance of the abnormalities allows a more accurate diagnosis of the cause of the pain.[2] The most important factors predisposing to patellar instability include trochlear dysplasia and patella Alta (high position of the patella).[3] There are other causes of AKP, such as chondral abnormalities, patellar instability and dislocation, femoral trochlear dysplasia, abnormal patellar location, bipartite patella, various tendinopathies, bursal inflammation, traction apophysitis in pediatric and adolescent patients, and

[1] Department of Surgery, College of Medicine, Hawler Medical University, Erbil, Iraq.
Correspondence: haven.azo@hmu.edu.krd

https://doi.org/10.15218/zjms.2022.017

miscellaneous diseases including mediopatellar plica syndrome and Hoffa's.[2] MRI is now acknowledged as a well established technique that has replaced diagnostic arthroscopy as the primary noninvasive diagnostic modality.[4]

Radiologists should pay great attention to MRI findings and follows a systematic approach in evaluating any case of AKP. There is a need to assess the diagnostic accuracy of MRI in evaluating patello-femoral instability with the main goal of allowing more accurate diagnosis and grading of some of the most common pathologies. This is important for understanding better treatment, avoiding unnecessary surgical interference, and improving this common complaint.

This study aimed to determine the causes of AKP and assess the role of MRI in evaluating cases of AKP and achieving accurate diagnosis and grading of some of the most common pathologies to help in better management and prognosis of the cases.

Methods

This cross-sectional study included 115 patients who suffered from knee joint pain, referred to the radiology department, Rizgary Teaching Hospital from rheumatological or orthopedic outpatient clinics, or private clinics between March 2017 and January 2020. The diagnosis of AKP and the related pathology was made by a radiologist with long term experience in MRI of the musculoskeletal system. A total of 34 patients had AKP, including 21 females and 13 males.

Their age was between 14-52 years old. All patients underwent an MRI examination using Siemens 1.5T with an extremity coil, a field of view of 200- to 200 mm, and a 256_ 256 matrix.

Our sequences included T1-sagittal intermediate-weighted fast spin-echo (FSE) (TR /TE, 333/11), T2 sagittal intermediate-weighted fast spin-echo (FSE) (TR /TE, 3000/741), coronal, sagittal, and axial proton density fat-suppressed T2-weighted FSE range (2220–2490/40–44).

MRI Study Analysis

Patello-femoral instability was detected as the main cause of AKP either due to morphological or joint geometrical abnormalities or post-trauma, so each case had been evaluated in a systematic way following these criteria:

1) High patella: Insall-Salvati index greater than 1.3.[5]

2) Patella Baja.[6]

3) Trochlear dysplasia has been based on the Dejours radiographic classification.[7]

Type A – trochlea with morphology preserved, but with a shallow trochlear sulcus (angle greater than145).

Type B – Flat oriented sulcus.

Type C – Asymmetrical trochlear facets, with hypoplasia of the medial facet and convexity of the lateral facet.

Type D – Type C + presence of a supra-trochlear ventral prominence more than or equal to 7mm.

4) Patellar translation should be assessed relative to the femur, which occurs more commonly laterally rather than medially.

A fine balance between medial and lateral stabilizers controls patellar tracking. Of these, the vastus medialis obliquus (VMO) and vastus lateralis obliqus (VLO) form the two most important dynamic restraints.

The VMO holds the patella flush against the femur in extension and neutralizes the lateral pull of the VLO.[8] Subluxation/ translation is measured as the distance between perpendicular lines drawn on an axial image from the medial edge of the patella through the most anterior point of the medial condyle[9] (Figure 1),[10] with 2 mm being the top normal distance.

The translation or subluxation can be further classified as mild (<5mm), moderate (5-10mm), and severe (>10 mm).[11]

It is remembered that the presence of joint effusion in itself might cause or exaggerate patellar subluxation.[10]

5) Patellar tilt had been assessed by patellofemoral angle on axial views.

https://doi.org/10.15218/zjms.2022.017

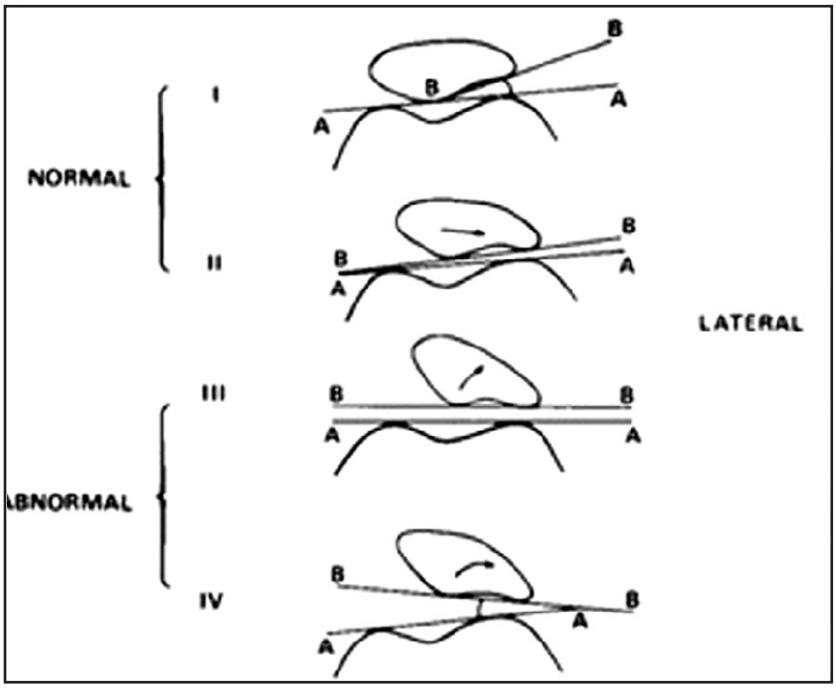

Diagram 1 Illustrating the patello-femoral angel. It normally measures >8_ and opens laterally. Medial opening or an angle <8_ qualifies as an abnormal tilt. PFA is measured between the lines drawn along the bony lateral patellar facet and another line tangent to the anterior femoral condyles.[4]

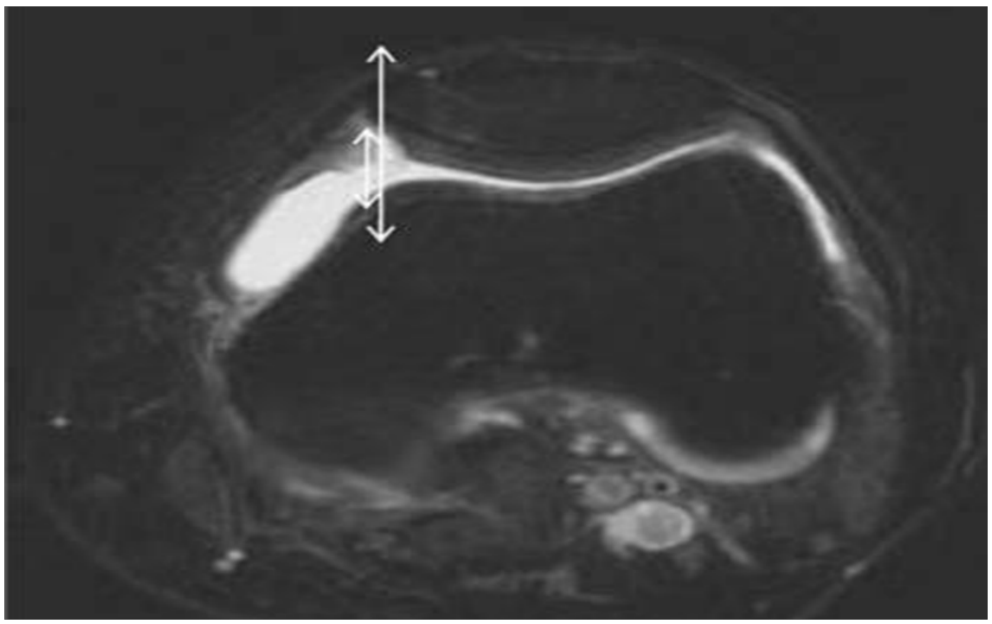

Figure 1 Normal patellar location with patellar apex congruent to femoral trochlear sulcus and less than 2 mm distance between lines drawn along the medial patellar facet (*short line*) and medial femoral trochlea (*longer line)*; axial T2WI.[10]

https://doi.org/10.15218/zjms.2022.017

The radiologist should look for abnormal patellar tilt, which may be present with or without patellar translation. Abnormal tilt without lateral translation has been referred to as excessive lateral pressure syndrome (ELPS).[10] The patellofemoral angle is a valid and easy measurement between the lines drawn along the bony lateral patellar facet and the tangent to the anterior femoral condyles.[10] It is measured at the level of the patellar midpoint, as referenced on sagittal imaging. In general, the normal patellofemoral angle measures more than 8° and opens laterally medial opening, or an angle less than 8° qualifies as abnormal tilt.[12]

6) Assessment of peripatellar fat pads, which includes the suprapatellar fat pad, the prefemoral fat pad, and the infrapatellar fat pad (Hoffa fat pad).[13]

A)Hoffa fat pad impingement disease or Patellar tendon-lateral femoral condyle friction syndrome (PT-LFCFS), which is defined as a focal area of high T2 signal (edema) at the inferolateral aspect of the patellofemoral joint, within the superolateral portion of the infrapatellar fat pad.[14]

B) Suprapatellar fat pad impingement syndrome, which is assessed by suprapatellar and prefemoral fat pad abnormal high T2 signal.[13]

7) The radiologist or researcher should look for MRI signs of chondromalacia patella and its grading.

grade I

- focal areas of hyperintensity with normal contour.
- arthroscopically: softening or swelling of the cartilage.

grade II

- blister-like swelling/fraying of articular cartilage extending to the surface.
- arthroscopically: fragmentation and fissuring within soft areas of articular cartilage.

grade III

- partial-thickness cartilage loss with focal ulceration.
- arthroscopically: partial thickness cartilage loss with fibrillation (crab-meat appearance).

grade IV

- full-thickness cartilage loss with underlying bone reactive changes.
- arthroscopically: cartilage destruction with exposed subchondral bone-15.

8) Signs of arthrosis should be assessed in the form of joint space narrowing in the lateral patellofemoral joint and the presence of osteophytes, effusion, and subchondral geod shader.

9) Plica assessment, at MR imaging, synovial supra or infra patellar plicae can be seen as bands of low signal intensity within the high-signal intensity joint fluid.[16]

Statistical analysis

The statistical package for the social sciences (SPSS version 23) was used for statistical analysis. The statistical analysis involved measuring the frequency and percentages and displaying them in tables.

Results

MRI examinations for 34 knees of 115 patients were done who had AKP,13 were male (38.24%), and 21 were female (61.76%) (Table 1). Most of the cases presented clinically with AKP, four cases presented with a history of pain after trauma. The patients' age ranged from 14 to 52 years, with a mean of 31 years.

Table 1 Distribution of the sample according to sex

Gender	No. of patients	(%)
Males	13	(38.24)
Females	21	(61.76)
Total	34	(100.00)

https://doi.org/10.15218/zjms.2022.017

Table 2 shows the prevalence of different pathological causes of AKP. Twelve cases (35.29%) have patella Alta (Figure 2), while two cases (5.8%) had patella Baja. Trochlear dysplasia was reported in seven cases (20.58%). Patellar maltracking (Figure 3) was seen in eight cases (23.52 %), and tilt of the patella (Figure 3) was seen in 10 cases (29.41%). Excessive lateral pressure syndrome (ELPS) was seen in two cases (5.40%), which is defined as patellar tilt without translation (10). Chondromalacia patella (Figure 4) was detected in six cases (17.64%), four (66.66%) in females, and two (33.33%) in male patients. Peripattelar fat pad edema was seen in four cases (11.76%), prefemoral fat pad impingement was observed in two female cases (50%), and two cases (50%) showed Hoffa fat pad impingement (PT-LFCFS). Osgood Schlatter disease (Figure 5) was seen in one male patient (2.94%). Thirty one patients (91.17%) showed signs of patellofemoral arthrosis, and joint effusion was seen in 30 patients (88.23%), ranging from mild to severe form. Suprapatellar plica was seen in two cases (5.40%).

Table 2 Prevalence of different pathological causes of AKP

Pathology	No. of patients	(%) n=34
Patella Alta	12	(35.29)
Patella Baja	2	(5.88)
Trochlear dystrophy	7	(20.58)
Patellar tilt	10	(29.41)
Patellar maltracking	8	(23.52)
Plica	2	(5.40)
Chondromalacia patella	6	(17.64)
Osgood Schlatter disease	1	(2.94)
Joint arthrosis	31	(91.17)
Joint effusion	30	(88.23)
Peripattelar fat pad	4	(11.76)
A) Hoffa fat pad impingement	2	(50.00)
B) Prefemoral fat pad impingement	2	(50.00)
ELPS	2	(5.40)

* Some patients had more than one pathology.

https://doi.org/10.15218/zjms.2022.017

Figure 2 Sagittal T2 proton fat suppressed, 20 years old male shows Patella Alta (insall-salvati index=PT(56mm)/PL(36.4)=1.53

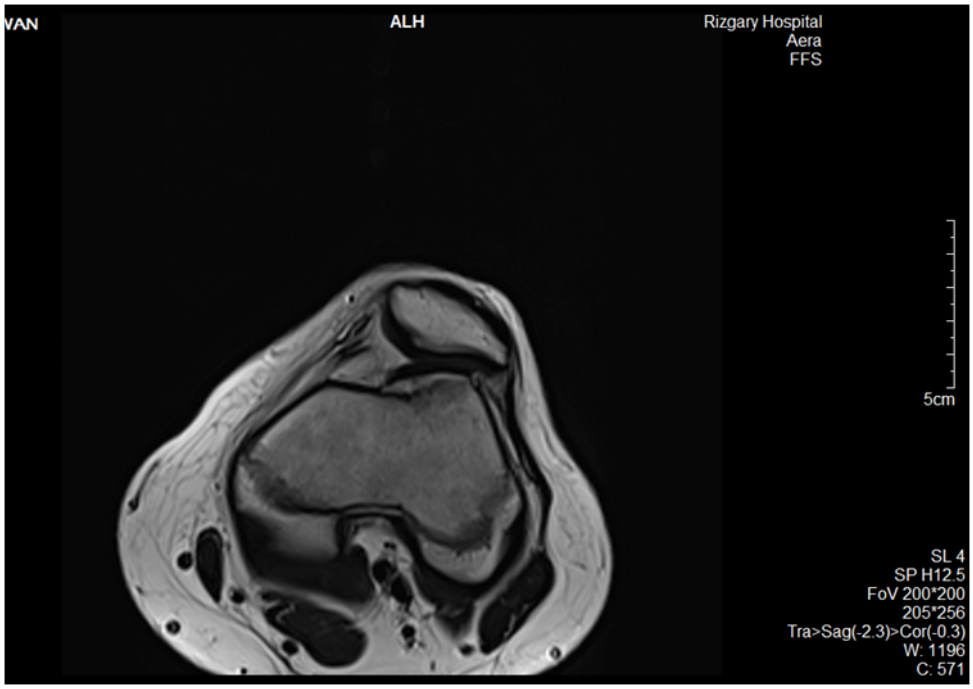

Figure 3 T1 axial image, 17 years old male patient shows Patellar translation & tilt

https://doi.org/10.15218/zjms.2022.017

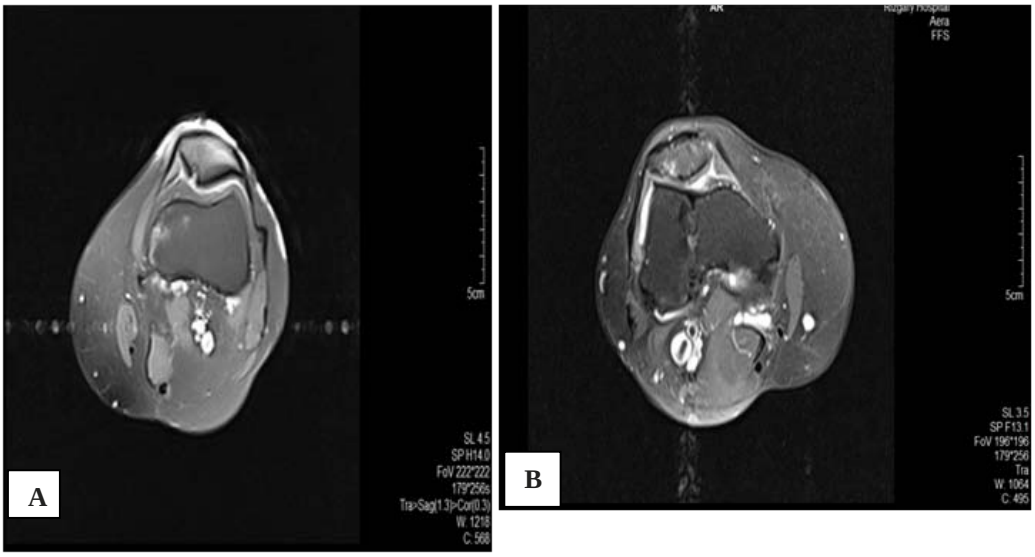

Figure 4 A T2 axial WI fat saturated image,44 years old female shows grade 4 chondromalacia, **B** Axial proton density fat saturated image, 46 years old female has chondromalacia grade 4

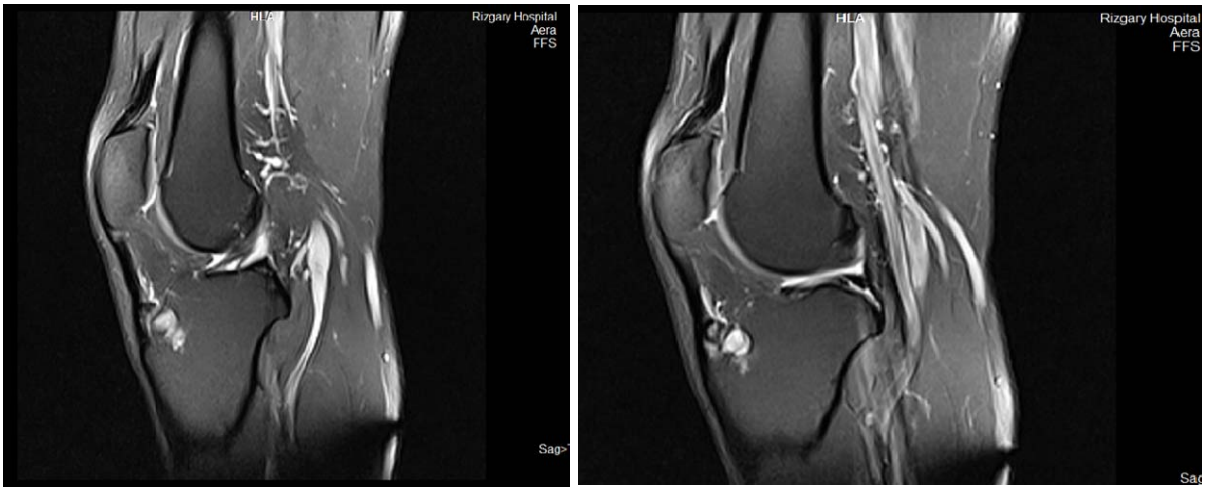

Figure 5 Sagittal T2 proton density fat suppression, 31 years old male shows chronic Osgood Schlatter disease manifested as abnormal T2 signal in tibial tubercle, heterogenous at inferior patellar tendon, loss of the sharp inferior angle of the Hoffa fat pad, and edema at Hoffa fat pad accompanied by underlying tibial subchondral cystic changes

https://doi.org/10.15218/zjms.2022.017

Regarding patellar maltracking, a combination of patellar tilt, Alta, and maltracking was seen in eight cases (23.52%), while six cases (17.64%) showed a combination between trochlear dysplasia, patellar tilt, and maltracking, as shown in Table 3.

Regarding trochlear dysplasia, type C was the most common type, which was seen in four cases out of seven (57.14) (Figure 3), followed by type B, which was seen in two cases (28.57%). Shallow trochlear groove (type A) was seen in one case (14.28%), while type D was not recorded, as shown in Table 4.

Regarding chondromalacia patella, for each grades of 2, 3, and 4, two cases were seen while grade one was not detected, as shown in Table 5.

Table 3 Prevalence of shared overlapped between the disease and pathology

Pathology	No. of patients	(%) n=34
Patella Alta		
Patella Alta alone	8	(23.52)
Patella Alta and tile	8	(23.52)
Patella Alta and translation	8	(23.52)
Trochlear dystrophy		
Trochlear dystrophy alone	7	(20.58)
Trochlear dystrophy and tilt	6	(17.64)
Trochlear dystrophy and translation	6	(17.64)

* Some patients had more than one pathology.

Table 4 Number and percentage of trochlear dystrophy

Trochlear dystrophy	No.	(%)
Type A	1	(14.28)
Type B	2	(28.57)
Type C	4	(57.14)
Type D	0	(0.00)
Total	7	(100.0)

Table 5 Number and percentage of chondromalacia and its grading

Grades of chondromalacia	No.	(%)
Grade I	0	(0.0)
Grade II	2	(33.3)
Grade III	2	(33.3)
Grade IV	2	(33.3)
Total	6	(100.0)

https://doi.org/10.15218/zjms.2022.017

Discussion

Anterior knee pain is the most common complaint among patients suffering from knee pain. In this study, 34 out 115 patients had AKP, which compromised 29.56%, which agrees with Fahmy et al.[4]

AKP in school-age students has been reported to be 7% in the 10–19 year age group (male and female), which relatively agrees with Fahmy et al.,[4] and this may be attributed to over activities were done during school time in unprofessional ways. In this study, the middle age and adult female patients reported having AKP more than males. Our results showed that 61.76% of the study sample were female, and 38.24%% were male. This finding agrees with Hanafi et al.,[17] who reported that 65% of their studied sample were female, and 35% were male. This can be attributed to the close regional social lifestyle, lack of exercise, and sitting for a long time, which predispose early arthrosis and can easily be injured.

In this study, the causes of AKP are categorized mainly by patello-femoral instability, patellar chondral causes, plica and bursitis, and miscellaneous. The patello-femoral instability includes patella Alta, patella Baja, patellar translation or maltracking, patellar tilt, and morphological and joint geometrical abnormality trochlear dystrophy. In this study, patella-femoral instability was reported as the main source of AKP, and this agrees with Biedert et al.[18] MRI is unquestionably superior to other imaging modalities for detecting morphological or joint geometry abnormalities that are predisposed toward patellofemoral instability. High patella beyond the physiological limits was reported in 35.29%, which relatively agrees with the 41.8% result of Fahmy et al. study.[4] Patella baja was seen in 5.88%, which relatively agrees with Fahmy et al.[4] which their percentage was about 3.63%, and this can be explained that both studies were done in two nearby countries whose people share a lot of social habits.

Trochlear dysplasia is considered to be one of the main risk factors for instability, which is assessed by sulcus angle, groove depth, and trochlear facet asymmetry.[19] In this study, trochlear dysplasia was present in 20.58%, which agrees with Hanafi et al.[17] in which trochlear dystrophy was present in 15% of their sample. However, our result disagrees with both of Fahmy et al.,[4] which was seen in about 63% of its sample.

Similarly, Souza et al. (2013) found trochlear dysplasia in 53%.[20] So, this may be attributed to different examined sample sizes, but even in the current study, more cases are reported having type C, and the least number was type D Trochlear Dystrophy, which agrees with Fahmy et al.[4] This study emphasized that recognizing these bone abnormalities is essential for evaluating the prognosis and planning the best therapeutic management, which agrees with Souza et al. in 2013,[20] who stated that MR imaging is an excellent method for diagnosing trochlear dysplasia. Patellar tilt was found in 29.41%, which comes in agreement with the 31% of Fahmy et al. result.[4] Patella maltracking was reported in 23.52%, which had been assessed by measuring the distance between the medial patellar facet to the most anteromedial part of trochlear facet; it comes in agreement with Souza et al. (24%).[20] TA-GT distance was not included in diagnostic MRI criteria because of overloading in MRI department. In most articles, patellar tilt and translation is defined as patellar instability. In the current study, both were around 52.93%, which is relatively in agreement with Souza et al.,[20] which gives 53% combined for 24% patellar translation and 29%for patellar tilt.

Fat pad edema is categorized into Hoffa fat pad impingement defined by MRI as superolateral aspect of the infrapatellar fat pad edema and bulging of patellar ligament. It was seen in one case (2.94%) who had patellar maltracking and patellar tilt. This result agrees with Chhabra et al.[10] and Jibri,[21] who stated most of the superiolateral infra fat pad edema is associated with patellar maltracking and

https://doi.org/10.15218/zjms.2022.017

tilt. This can be explained by factors that positively induce excessive friction or pressure of the lateral patellar facet over the lateral femoral condyle, resulting in superolateral Hoffa's fat pad edema. Prefemoral fat pad edema had been reported in two cases (5.88%) who had patellar maltracking, which agrees with Bell and Dixon et al.,[14] who stated perfemoral fat pad bursitis is one of the causes of AKP. However, this finding disagrees with Jarraya et al.,[13] who stated that there is no association between prefemoral fat pad impingement and patellar maltracking. This may explain the patient in this study had a history of trauma and sign of arthrosis (osteophyte) at patellofemoral joint, which caused friction between the fat pad, femoral ostyphtes, and subluxed patella.

Identifying edema at the superolateral aspect of Hoffa's fat pad and prefemoral fat pad on MRI should prompt the reporting radiologist to look for features of patellar maltracking.

Chondromalacia patella was detected in six cases (17.6%), four in female and two in male patients. This agrees with Grelasmer et al.[22] also reported that chondromalacia patella is more common in female adolescents and young adults. Osgood Schlatter disease was seen in one male patient (2.94%), which comes in relative agreement with Hanafi et al. when one male case was reported in their study (5%). Joint arthrosis was seen in 75%, which disagrees with Fahmy et al., who reported only 22%. No quadriceps or patellar tendon rupture was recorded.

One of the limiting factors of MRI is the physiological lateralization and inclination of the patella in extension. Evaluating these parameters should be done with the knee flexed, which is not routine in MR imaging of the knee joint. For this reason, the examination needs to be guided by a radiologist who is familiar with the recommended protocols for evaluating instability using MRI, as well as the need for the availability of apparatus and coils that allow image acquisition in this position. Despite these limitations, the capacity to combine the evaluation of bone, cartilage, and soft-tissue structures is made.

This study has several limitations. The sample size was relatively small for the duration of the study, and such a common problem. This was because the experience and findings of only one radiologist were documented. Future studies need to combine the efforts of several radiologists and MRI centers to have a larger sample with more generalizable findings. In the current study, the diagnosis was not confirmed by arthroscopy or operative findings, and there was no follow-up or reporting management results. Further studies need to consider these aspects.

Conclusion

The most common cause of AKP is patellofemoral instability, either due to abnormal morphology /or joint geometry, or post-traumatic. It is occasionally caused by a serious underlying systemic disease, including inflammatory conditions and malignancies. Anterior knee pain is occasionally caused by serious underlying systemic disease, including inflammatory conditions and malignancies. MRI offers superior soft tissue contrast resolution and allows for a more accurate evaluation of the underlying etiology and, therefore, may improve treatment and management.

Funding

Not applicable.

Competing interests

The author declares that she has no competing interests.

References

1. Sanchis-Alfonso V, McConnell J, Monllau JC, Fulkerson JP. Diagnosis and treatment of anterior knee pain. Journal of ISAKOS: Joint Disorders & Orthopaedic Sports Med. 2016; 1(3):161–73. https://doi.org/10.1136/jisakos-2015-000033
2. Samim M, Smitaman E, Lawrence D, Moukaddam H. MRI of anterior knee pain. Skeletal Radiol. 2014;43(7):875–93. https://doi.org/10.1007/s00256-014-1816-7

3. Diederichs G, Issever AS, Scheffler S. MR imaging of patellar instability: injury patterns and assessment of risk factors. Radiographics. 2010;30(4):961–81.https://doi.org/10.1148/rg.304095755
4. Fahmy HS, Khater NH, Nasef NM, Nasef NM. Role of MRI in assessment of patello-femoral derangement in patients with anterior knee pain. Egypt J Radiol Nucl Medicine. 2016;47(4):1485–92. https://doi.org/10.1016/j.ejrnm.2016.07.020
5. Lu W, Yang J, Chen S, Zhu Y, Zhu C. Abnormal patella height based on Insall-Salvati ratio and its correlation with patellar cartilage lesions: An extremity-dedicated low-field magnetic resonance imaging analysis of 1703 Chinese cases. Scand J Surgery. 2016;105(3):197–203. https://doi.org/10.1177/1457496915607409
6. Thurston M, Gaillard F. Patella baja. Radiopedia. (Accessed March 6, 2021, at https://radiopaedia.org/articles/patella-baja).
7. Stepanovich M, Bomar JD, Pennock AT. Are the current classifications and radiographic measurements for trochlear dysplasia appropriate in the skeletally immature patient? Orthop J Sports Med. 2016;4(10):2325967116669490. https://doi.org/10.1177/2325967116669490
8. Stoller DW, editor. Magnetic resonance imaging in orthopaedics and sports medicine. New York: Lippincott Williams & Wilkins; 2007.
9. Katchburian MV, Bull AM, Shih YF, Heatley FW, Amis AA. Measurement of patellar tracking: assessment and analysis of the literature. Clin Orthop Relat Res. 2003;412:241–59. https://doi.org/10.1097/01.blo.0000068767.86536.9a
10. Chhabra A, Subhawong TK, Carrino JA. A systematised MRI approach to evaluating the patellofemoral joint. Skeletal Radiol. 2011;40 (4):375–87. https://doi.org/10.1007/s00256-010-0909-1
11. McNally EG, Ostlere SJ, Pal C, Phillips A, Reid H, Dodd C. Assessment of patellar maltracking using combined static and dynamic MRI. European Radiol. 2000;10(7):1051–5. https://doi.org/10.1007/s003300000358
12. Ye Q, Yu T, Wu Y, Ding X, Gong X. Patellar instability: the reliability of magnetic resonance imaging measurement parameters. BMC Musculoskelet Disord. 2019;20:317. https://doi.org/10.1186/s12891-019-2697-7
13. Jarraya M, Diaz LE, Roemer FW, Arndt WF, Goud AR, Guermazi A. MRI findings consistent with peripatellar fat pad impingement: how much related to patellofemoral maltracking? Magn Reson Med Sci. 2018;17(3):195. https://doi.org/10.2463/mrms.rev.2017-0063
14. Bell D, Dixon A. Patellar tendon-lateral femoral condyle friction syndrome. Radiopedia. (Accessed March 6, 2021, at https://images.radiopaedia.org/articles/patellar-tendon-lateral-femoral-condyle-friction-syndrome-1).
15. Slattery C, Kweon CY. Classifications in brief: Outerbridge classification of chondral lesions. Clin Orthop Relat Res. 2018;476(10):2101. https://doi.org/10.1007/s11999.0000000000000255
16. Kheiralla OA. Imaging appearances of synovial plicae syndrome of the knee. Int J Med Res Health Sci. 2016;5(8):140–9.
17. Hanafi HM, Aldiasty SE, Abbood AJA. Role of MRI in evaluation of anterior knee pain. Egypt J Hosp Med. 2018;70(9):1552–61. https://doi.org/10.12816/0044682
18. Biedert RM, Sanchis-Alfonso V. Sources of anterior knee pain. Clin Sports Med 2002; 21(3):335–47. https://doi.org/10.1016/S0278-5919(02)00026-1
19. Escala JS, Mellado JM, Olona M, Giné J, Saurí A, Neyret P. Objective patellar instability: MR-based quantitative assessment of potentially associated anatomical features. Knee Surgery, Sports Traumatology, Arthroscopy. 2006;14 (3):264–72. https://doi.org/10.1007/s00167-005-0668-z
20. Souza PM, Gabetto MS, Serrao MG, Vieira LA, Oliveira DC. Patellofemoral instability: evaluation by magnetic resonance imaging. Rev Bras Ortop. 2013;48(2):159–64. https://doi.org/10.1016/j.rbo.2012.04.001
21. Jibri Z, Jamieson P, Rakhra KS, Sampaio ML, Dervin G. Patellar maltracking: an update on the diagnosis and treatment strategies. Insights Imaging. 2019;10(1):65. https://doi.org/10.1186/s13244-019-0755-1
22. Grelsamer RP. Patellar nomenclature: the Tower of Babel revisited. Clin Orthop Relat Res. 2005;436:60–5. https://doi.org/10.1097/01.blo.0000171545.38095.3e