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Role of Magnetic Resonance Imaging in Evaluation of Anterior Knee Pain

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ABSTRACT

Background: the term "anterior knee pain" is often used interchangeably with "Patellofemoral pain syndrome PFPS" or "runner's knee". PFPS can be defined as anterior knee pain involving the patella and retinaculum. **Aim of the Work:** to highlight the role of magnetic resonance imaging (MRI) in the diagnosis and grading of the most common causes of anterior knee pain. **Patients and Methods:** this study included fifty patients, their ages range between 10-60 years (average age 27 years). All presented with anterior knee pain (AKP) and were referred to the Radiology Department of El-Demerdash Hospital for MRI examination after orthopedic consultation. **Results:** the role of MRI in the diagnosis and grading of the most common causes of anterior knee pain have been shown in this study. These causes have been classified in to five disease categories; Patellar abnormalities represented most of them (64% of the sample size) and they included chondromalacia patella, patellar instability, transient patellar dislocation and painful bipartite patella. Hoffa's diseases represented 12% of the sample size and they included Hoffa impingement syndrome and Hoffa fibrotic bands. Patellar tendon disorders represented 6 % of the sample size and they included Patellar Tendinopathy and Osgood Schlatter Disease. Quadriceps tendon disorders represented 4% of the sample size and they included Quadriceps Tendinopathy. Other causes represented 14% of the sample size and they included torn anterior horn of the lateral meniscus and cartilage injuries. **Conclusion:** many factors may cause anterior knee pain. MRI is generally safe, non-ionizing, non-invasive and valuable imaging technique which has been proven to be the modality of choice for establishing an accurate diagnosis of different knee pathologies that cause anterior knee pain in different age groups. It also allows to know the extent, severity, grades and types of the lesions, what will be necessary to decide appropriate treatment. **Recommendations:** further studies on a larger scale of patients are needed to confirm the results obtained by this work.

Keywords: MRI, anterior knee pain.

INTRODUCTION

Anterior knee pain (AKP) is the most common knee complaint, usually occurring in adolescents and young adults [(1)].

Previous studies on prevalence estimates of anterior knee pain in childhood and adolescence vary widely from 3 to 40 % [(2)].

Despite its high prevalence, the etiology and differential diagnosis remains a challenge for the treating physician, mainly due to the fact that there are no specific clinical signs, and the term ''anterior knee pain'' encompasses a wide spectrum of disorders [(3)].

Magnetic resonance imaging (MRI) in the recent decades has become the gold standard imaging modality for different knee pathologies as it is safe, and RF pulses used in MRI do not cause ionization. With MRI, we can obtain direct coronal and oblique images which are impossible with radiography and CT. Particularly useful for the scanning and detection of abnormalities in soft tissue structures like the cartilage tissues, tendons, and ligaments. MRI also can help determine which patients with knee injuries require surgery. MR imaging is recognized as a standard procedure and has replaced diagnostic arthroscopy as the primary diagnostic modality for many knee pathologies. Moreover, MR images can be used to assess anatomic variants that may contribute to chronic patellar instability [(4)].

AIM OF THE WORK

To highlight the role of magnetic resonance imaging (MRI) in the diagnosis and grading of the most common causes of anterior knee pain.

PATIENTS AND METHODS

This study included fifty patients, their ages range between 10-60 years (average age 27 years). All presented with anterior knee pain (AKP) and were referred to the radiology department of El-Demerdash hospital for MRI examination after orthopedic consultation. **The study was approved by the Ethics Board of Ain Shams University.**

Inclusion criteria

Any patient complaining of anterior knee pain (AKP).

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Exclusion criteria

Patients with contraindications to MRI examination as:

- Aneurysmal clipping.
- Claustrophobia.
- Cardiac pace maker.

MRI examination of the affected knee joint was performed for all patients after taking history and, if clinically indicated, plain X-ray of the affected knee joint was also performed.

- **History Taking:**

- Present history: Analysis of patients complaint (anterior knee pain): site, onset, course, duration, aggravating and relieving factors, and the relationship to posture. Also if there is any associated symptoms as stiffness, swelling, and deformity.
- Past history: previous surgery or trauma.
- Personal history: age, sex, and occupation.

Technique

- Patients Positioning:

The patients were positioned supine with the affected knee completely or nearly completely extended in the knee coil.

- MRI Examination:

MRI was performed by using knee coil for all patients.

Patients had MRI examination of the affected knee joints on high field-strength scanners using Philips scannres Achieva or Intera (1.5 T).

- Protocol:

MRI imaging sequences:

The MRI study included some or all of the following pulse sequences:

- Sagittal T1 WIs.
- Sagittal T2 WIs.
- Sagittal PD WIs.
- Sagittal STIR or PD fat saturation.
- Axial T2WIs.
- Axial STIR.
- Coronal T2 FFE WIs or STIR.

Table (1): MRI sequences parameters on high field strength scanners.

Parameters	Sagittal T1	Sagittal T2	Sagittal STIR	Sagittal PD	Coronal T2 FFE	Axial T2
TR	600	3600	2400	1620	380	3600
TE	17	100	60	30	13	100
FOV Anterior/ Posterior	30	30	30	30	30	20
Right/ Left	35	35	50	35	50	60
Feet/ Head	50	50	20	50	20	40

The following parameters were applied:

- Matrix size 256/192 or 512/224.
- Field of view ranged from 12 to 16 cm.
- Slice thickness 4 mm.
- Slice gap 4 mm.
- The average duration time of the examination ranged from 25-30 minutes.

All cases of Chondromalacia Patella had the following grading system depending on *International Cartilage Repair Society (ICRS)* and *Outerbridge* grading systems [(5)].

Table (2): MRI grading of chondromalacia patella

Grade	MRI appearance
Grade I	Focal areas of hyper intensity with normal contour
Grade II	Blister- like swelling/ fraying of the articular cartilage extending to the surface with less than 50% thickness cartilage loss
Grade III	More than 50% thickness cartilage loss with focal ulceration
Grade IV	Full thickness cartilage loss with underlying bone reactive changes

In suspected cases of Patella Alta (PA), we used *Insall-Salvati index* for assessment of the patellar height, which is calculated as the length of the patellar tendon measured posteriorly from the apex of the patella to its attachment to the tibial tuberosity, divided by the longest superoinferior diameter of the patella. Patella alta is defined as the patellar height ratio of more than 1.3 (normal is 0.8 to 1.1) [(6)].

In individuals with Trochlear Dysplasia, *D. Dejour's* classification is used which include four types:

Table (3): Classification of trochlear dysplasia [(7)]

Type	MRI appearance
Type A	Normal shape of the trochlea preserved but a shallow trochlear groove.
Type B	Markedly flattened or even convex trochlea.
Type C	Asymmetric trochlear facets, with the lateral facet being too high and the medial facet being hypoplastic, which results in the flattened joint surface forming an oblique plane.
Type D	In addition to the features of type C, a vertical link between medial and lateral facets (cliff pattern on parasagittal images).

In case of patellar maltracking, we measure the following different parameters for the evaluation of the trochlear dysplasia:

- Lateral trochlear inclination (LTI): It was defined on the MR-slices at about 3 cm above the femorotibial joint space by measuring the angle between a line tangential to the subchondral bone of the posterior aspects of the femoral condyles and a line tangential to the subchondral bone of the lateral trochlear facet. An angle of <11º is considered abnormal [(8)].
- Trochlear facet asymmetry: MRI slices at about 3 cm above the tibiofemoral joint space were use. Trochlear facet asymmetry was expressed with the relation of medial trochlear facet width (e) to lateral trochlear facet width (f) ([e/f] X 100%). A ratio of less than 0.4 is considered abnormal which means that the medial facet is less than 40% the width of the lateral one [(9)].
- Depth of the trochlear groove: MRI slices at about 3 cm above the tibio-femoral joint space were used for the assessment of the trochlear depth by measuring the maximal antero-posterior distance of the medial frmoral condyle (distance a) and lateral femoral condyle (distance b), and the minimal antero-posterior distance between the deepest point of the trochlear groove and the line paralleling the posterior outlines of the femoral condyles (distance c). Trochlear depth was calculated by the formula ([a+b]/2)-c). Trochlear dysplasia is assumed if the trochlear depth is 3 mm or less [(7)].

Statistical Analysis

The collected data were revised, coded, tabulated and introduced to a PC using Statistical Package for Social Science (SPSS 15.0.1 for windows; SPSS Inc, Chicago, IL, 2001). Data were presented as Mean and Standard Deviation (±SD) for quantitative parametric data, and Median and Interquartile range for quantitative non-parametric data. Frequency and percentage were used for presenting qualitative data. Suitable analysis was done according to the type of data obtained. Student t-test or Mann Whitney test was used to analyze quantitative data, while chi square test and Fisher exact test were used to analyze qualitative data. P-value of significance:

- P>0.05 : Non-Significant (NS)
- P<0.05 : Significant (S)
- P<0.01 : Highly Significant (HS)

RESULTS

This study included 50 patients complaining of anterior knee pain, with their ages ranged between 10-60 years. The descriptive statistics for age of the patients are shown in Table 4.

Table (4): The descriptive statistics of the age of the patients' sample

	Minimum	Maximum	Average ± SD
Age	12	60	26.76 ± 10.00

Out of the 50 patients, 31 were females and 19 were males. Table 6 shows the percentage and the average age for each sex.

Table (5): Distribution of the sample according to sex

	No of patients	Percentage	Average(age)
Females	31	62%	27.41
Males	19	38%	25.68
No. of Patients	50	100%	

Table (6): Percentages of the prevalence of different causes of AKP by sex

	Patients	Female	Male
Patellar Causes	32	22	10
	64%	68%	32%
Hoffa disease	6	4	2
	12%	67%	33%
Patellar tendon causes	3	1	2
	6%	33%	67%
Quadriceps tendon causes	2	1	1
	4%	50%	50%
Miscellaneous	7	3	4
	14%	43%	57%

Table (7): Demonstrates the prevalence of 10 diseases entity found among the patients in the study sample.

	No. of Patients	Percentages of Patients
Chondromalacia Patella	20	40%
Patellar instability	8	16%
Hoffa disease	6	12%
Anterior Meniscal Tear	5	10%
Transient patellar dislocation	3	6%
Quadriceps Tendinopathy	2	4%
Osgood Schlatter disease	2	4%
Cartilage injury	2	4%
Patellar Tendinopathy	1	2%
Bipartite patella	1	2%
Sum	50	100%

Table (8): Demonstrates percentage of sex prevalence among different diseases.

	Female	Male	Sum
Chondromalacia Patella	14	6	20
	70%	30%	
Hoffa disease	4	2	6
	67%	33%	
Chronic Patellar instability	6	2	8
	75%	25%	
Transient patellar dislocation	2	1	3
	67%	33%	
Quadriceps tendinopathy	1	1	2
	50%	50%	
Patellar tendinopathy	1	0	1
	100%	0%	
Osgood Schlatter disease	0	2	2
	0%	100%	
Cartilage injury	0	2	2
	0%	100%	
Bipartite patella	0	1	1
	0%	100%	
Anterior Meniscal Tear	3	2	5
	60%	40%	

Table (9): Percentage of patellar instability and transient patellar dislocation

		No. of patients	Percentage
Patella Dislocation	Patellar instability	8	72.72%
	Transient patellar dislocation	3	27.27%
	Sum	11	100.00%

This table shows that 72% and 27% respectively out of total number of patellar dislocation (11 patients).

Table (10): Percentage of prevalence of different grades of chondromalacia patella

	Grade I	Grade II	Grade III	Grade IV	Grand Total
No. of Chondromalacia Patella patients	2	4	5	9	20
Percentages of chondromalacia Patella patients	10%	20%	25%	45%	100%

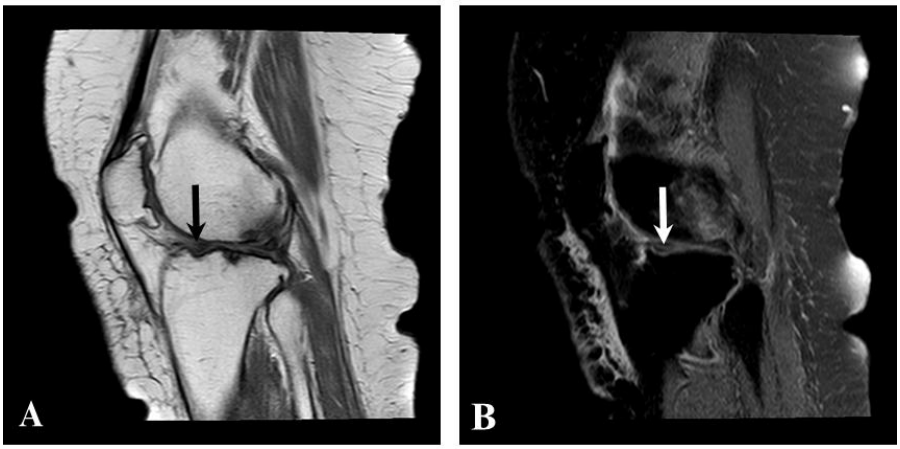
Table (11): Demonstrates percentage of different grades of trochlear dysplasia among the patients with patellar instability.

	Type A	Type B	Type C	Grand Total
No. of Trochlear dysplasia patients	2	2	1	5
Percentages of Trochlear dysplasia patients	40%	40%	20%	100%

Case

Clinical presentation:

47 year old female presented by anterior knee pain, swelling and stiffness following trauma.



Description

A. Sagittal T2-WI and B. Sagittal fat supression PD-WI demonstrate horizontal linear band of abnormal signal intensity within the anterior horn of the lateral meniscus reaching the inferior articular surface (arrows), with minimal joint effusion.

Diagnosis:

Torn anterior horn of the lateral meniscus.

DISCUSSION

Anterior knee pain (AKP) is the most common knee complaint, usually occurring in adolescents and young adults [(1)].

MRI is considered the best imaging modality for assessing the soft tissues in and around the knee joint for a more precise evaluation of the true cause or severity of anterior knee pain (AKP), thereby affecting decisions about appropriate surgical or conservative management [(10)].

The purpose of this study is to highlight the role of magnetic resonance imaging (MRI) in the diagnosis and grading of the most common causes of anterior knee pain.

The study included 50 patients, 31 were females and 19 were males, with their ages ranged between (10-60 years), all of them suffering from anterior knee pain.

Diederichs *et al*. [7] reported that anterior knee pain (AKP) may affect up to one third of adolescents at any time. The majority of patients are females and the symptom most commonly occurs in the second and third decades of life.

In our results, about 62% of the study sample were females with their average age 27 years and 38% were males with their average age 25 years.

Our study results showed that there was a significant difference between the number of AKP in males and females patients.

In our study, we divided the pathological process causing the symptom of anterior knee pain in a fashion similar to that proposed by **McNally *et al*.** [11] to five categories according to location and anatomical structure affected as following:

- Patellar tendon disorders.
- Quadriceps tendon disorders.
- Patellar disorders.
- Hoffa's diseases.
- Miscellaneous causes including anterior meniscal tear and cartilage injuries.

In our study, each category represented the following percentages:

- Patellar tendon disorders represented 6 % of the sample size and they included (Patellar Tendinopathy 2% and Osgood Schlatter Disease 4%).
- Quadriceps tendon disorders represented 4% of the sample size and they included Quadriceps Tendinopathy.
- Patellar disorders represented 64% of the sample size and they included (chondromalacia patella 40%, patellar instability 16%, transient patellar dislocation 6% and painful bipartite patella 2%).
- Hoffa's diseases represented 12% of the sample size and they included (Hoffa impingement syndrome and Hoffa fibrotic bands).
- Miscellaneous causes represented 14% of the sample size and they included (torn anterior horn of the lateral meniscus 10% and cartilage injury 4%).

1. Chondromalacia Patella:

Grelsamer [12] reported that Chondromalacia Patella is more common in female adolescents and young adults and this was matched with our study (70% females, 30% males and average age 26 years). Comparing to 0.05 level of significance, the P-value (0.03) of Chi-Square-Test shows that there is a significant difference between the prevalence of chondromalacia patella between males and females.

Mattila *et al.* [13] reported that MRI diagnostic accuracy is higher for high grade lesions (grade III and IV), and that was concordant with our study in which 45% of chondromalacia patella cases were grade IV, 25% grade III, 20% grade II and 10% grade I.

2. Osgood Schlatter Disease:

Gottsegen ***et al***. [14] have defined Osgood Schlatter Disease as an apophyseal traction injury of the tibial tubercle, caused by repetitive microtrauma. It is most common among adolescent male athletes.

Niitsu [15] also stated that if the tibial surface is not yet ossified, radiography may not reveal any abnormalities, so MRI is the best modality to detect early cases of OSD.

In our study, 4% (2 patients) had an MRI evidence of Osgood Schlatter disease, both of them were males under 25 years.

3. Patellar Tendinopathy:

Benjamin *et al*. [16] stated that patellar tendinopathy is one of the most common tendon abnormalities in young active individuals.

MRI findings of patellar tendinopathy include; focal thickening of the proximal one-third of the tendon, an AP diameter greater than 7 mm, and focal T2 hyperintensity within the proximal tendon, usually involving the medial one-third of the tendon [17].

In our results, 2% of the patients (28 years old), presented with anterior knee pain showed MRI evidence of patellar tendinopathy. The hyperintense focal thickening was at the proximal third of the tendon, with the AP diameter of the patellar tendon greater than 8 mm, and that was concordant with the study of **Samim *et al***. [17] as regard to the MR features of patellar tendinitis.

4. Quadriceps Tendinopathy:

Pfirrmann *et al*. [18] stated that MRI can visualize variable degrees of quadriceps tendon thickening and intra substance hyper intensity with maintained fibers continuity

In our results, about 4% of patients who presented by anterior knee pain had quadriceps tendon thickening with high signal intensity yet intact fibers denoting quadriceps tendinopathy.

5. Anterior Meniscal Tears

McNally *et al*. [11] mentioned that anterior meniscal tear and cartilage injuries are considered major causes of anterior knee pain. MR imaging is the most powerful, accurate and non-invasive method for diagnosis of meniscal tears. It is more accurate than physical examination and has influenced patient care and clinical practice by eliminate unnecessary diagnostic arthroscopy or by identifying an alternative diagnosis whose clinical presentation mimic meniscal tears.

Goldstein and Zuckerman [19] reported that meniscal injuries are common in young individuals who are involved in sporting or manual activities. A second peak of incidence is observed in elderly persons older than 55 years; this incidence is secondary to a degenerated meniscus being susceptible to injuries with minor trauma.

In our results, about 10% of the patients in the study sample, had MRI evidence of tear in the anterior horn of lateral meniscus. 80% of them had a history of trauma with their average age was 24 years. 20% were above the age of 45 years with no past history of knee trauma.

6. Articular Cartilage Injuries:

They are common and clinically can mimic meniscal tears. They have been associated with a less satisfactory clinical outcome following arthroscopy. Thus MRI prior to surgical intervention is valuable to evaluate for isolated articular cartilage injuries, help to predict prognosis and identify patients who may benefit from cartilage replacement therapies. Acute or repetitive trauma can cause a variety of articular cartilage injuries, including fissures, chondral flaps or tears, and loss of a segment of articular cartilage. These injuries may be isolated or more commonly associated with other intra articular injuries [20].

In our results, cartilage injuries were detected in 4% (2 patients) of the study sample, both of them were males with average age 18 years, also both of them had a past history of trauma.

7. Patellar Dislocation:

MRI is considered as a standard procedure and has replaced diagnostic arthroscopy as the primary diagnostic modality. MRI has been shown to be a highly sensitive cross-sectional imaging modality for assessing capsular, ligamentous, cartilaginous, and bone injuries associated with patellar dislocation [7].

Diederichs *et al*. [7] reported that most patients with patellar dislocation are young and active individuals, with women in the second decade of life having a high risk. In our study, patellofemoral instability (i.e. transient patellar dislocation) was detected in 6% of patients, with young females predominance (67% females with average age 28 years and 33% males).

Diederichs *et al*. [7] stated that disruption of the medial patellar retinaculum, is visualized on MRI in 70%–100% of the patients examined after lateral patellar dislocation. In our study, 67% of patients showed abnormalities in the medial patellar retinaculum.

Diederichs ***et al***. [7] reported that the majority of patients will show subluxation or tilt of the patella at MRI. In our study, all patients had abnormal lateral patellar position.

Diederichs *et al*. [7] reported that bone edema resulting from contusion of the medial aspect of the patella and the femoral condyle is a typical finding after patellar dislocation. In nearly all of the patients (80%–100%), bone edema of the lateral femoral condyle resulting from impaction of the patella will be seen. In our study, 100% showed contusions of the lateral femoral condyle and medial patellar facet.

Diederichs *et al*. [7] reported that knee joint effusion is a typical finding after patellar dislocation and will be seen in most patients, especially when imaging is performed immediately after the event. In our study, all patients had MRI evidence of joint effusion.

8. Patellar Instability:

Dejour and Coultre [21] described trochlear dysplasia and patella alta as two of the most important predisposing factors for patellar instability and recurrent patellar dislocation.

Because of X-ray difficulty, and lack of accuracy, MRI with its multi-planner reformatting privilege has become the basic tool to assess trochlear dysplasia *(Salzmann* ***et al****., 2010).*

Dejour and Le Coultre [21] reported that the trochlear dysplasia type A represent 54%, type B 17%, and type C 9%.

In our study, we founded that 16% of the patients had patellofemoral pain with malalignment (i.e. chronic patellar instability) and showing MRI evidence of trochlear dysplasia. 40% categorized as type A, 40% as type B, and 20% as type C according to *Dejour* ***et al*** classification.

Diederichs *et al*. [7] mentioned that techniques for quantifying the degree of dysplasia have been standardized for MR imaging. Trochlear dysplasia can be evaluated at MR imaging by determining lateral trochlear inclination, trochlear facet asymmetry, or trochlear depth.

Diederichs *et al*. [7] reported that the threshold for trochlear dysplasia is an inclination angle of 11°, with an inclination angle of less than 11° indicating trochlear dysplasia.

***Pfirrmann et al*.** [9] calculated the depth of the trochlear groove and trochlear facet asymmetry 3cm above the femorotibial joint. They found that trochlear groove depth less than 3mm and facet asymmetry of less than 40% are diagnostic value for trochlear dysplasia.

In our study, of all patients with trochlear dysplasia, 50% had lateral trochlear inclination of less than 11◦, 25% had trochlear groove depth of less than 3 mm and 25% had facet asymmetry of less than 40%.

***Barnett et al*.** [6] stated that the normal patellar height ratio is 1.1 (standard deviation, 0.1). Patella alta is defined as a patellar height ratio of more than 1.3, which is the normal ratio plus two standard deviations.

In our study, on MR imaging, 8% of patients with anterior knee pain had patellar height ratio of more than 1.3, denoting patella alta.

9. Bipartite Patella:

It represents failure of the fusion of the secondary ossification centers of the patella [22].

Samim *et al*. [17] mentioned that there are 3 types of bipartite patella according to *Saupe* ***et al*** classification. The 1st type involves the inferior pole of the patella, the 2nd type involves the lateral margin of the patella, and the 3rd type, the most common type, involves the superolateral pole.

In a study by **Kavanagh *et al*.** [23], bone marrow edema within the bipartite fragment was the sole finding in 49 % of the patients with bipartite patella.

In our study, 2% of the patients (1/50) with anterior knee pain had symptomatic bipartite patella of the third type (at the superolateral patellar pole) and had MRI evidence of subchondral oedema at the opposing surfaces probably denoting stress effects/ contusion.

10. Hoffa disease:

Chung *et al*. [24] studied 50 patients with anterior knee pain and reported that 50% of the sample had Hoffa impingement syndrome with female predominance.

In our study, only 12% of patients showed Hoffa disease with respect to female predominance to account for about 67% of the sample size, and males percentage was 33%. So, our study is concordant with **Chung *et al*.** [24] study as regard to the sex predominance, but differ in prevalence and this might be explained by the difference in the criteria of the selected sample between the two studies, as **Chung *et al***. excluded patients outside the ages of 14–50 years or those with a history of direct trauma to the knee, but in our study both were included.

CONCLUSION

Many factors may cause anterior knee pain. MRI is generally safe, non-ionizing, non-invasive and valuable imaging technique which has been proven to be the modality of choice for establishing an accurate diagnosis of different knee pathologies that cause anterior knee pain in different age groups. It also allows to know the extent, severity, grades and types of the lesions, what will be necessary to decide appropriate treatment.

Recommendations

Further study with larger number of patients is recommended.

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