MRI EVALUATION OF INTERNAL DERANGEMENT OF KNEE

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ABSTRACT

BACKGROUND

Internal derangement of knee means loss of normal knee function due to ligament or meniscal injuries. MRI is a routinely utilised noninvasive modality for evaluation of various knee disorders including internal derangement. MRI provides excellent soft tissue contrast and multiplanar images when compared to other musculoskeletal imaging modalities.

The aim of the study is to study the demographic profile of patients presenting with internal derangement of knee, identify the various ligament and meniscal injuries causing internal derangement of knee and describe the MRI features of the ligament and meniscal injuries.

MATERIALS AND METHODS

This study was undertaken from January 2016 to mid-December 2017 in the Department of Radiodiagnosis, MVJ Medical College and Research Hospital, Hoskote. The study population consisted of 108 patients with internal derangement of knee who underwent MRI of knee. All the MRI scans of the knee in this study were performed using Siemens Magnetom Essenza (A Tim+Dot system) MR machine with a 1.5 tesla field strength magnet using a flex coil.

RESULTS

The study population consisted of 108 patients comprising of 90 males and 18 females. The age of the patients ranged from 16 to 67 years. Majority of the patients belonged to the age group of 21-30 years constituting about 41% of the total study population. Anterior cruciate ligament injury was the commonest followed by medial and lateral meniscus tears. Flap tear was the commonest type of meniscal tear. Posterior horn of the meniscus was the commonest tear site.

CONCLUSION

MRI is the investigation of choice in evaluating internal derangement of knee. MRI can accurately diagnose ligament and meniscal injuries and guide arthroscopy.

KEYWORDS

Internal Derangement of Knee, MRI of Knee, Meniscal and Ligament Tears, Anterior and Posterior Cruciate Ligaments.

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BACKGROUND

Internal derangement of knee means loss of normal knee function due to ligament or meniscal injuries. MRI is a routinely utilised noninvasive modality for evaluation of various knee disorders including internal derangement. MRI provides excellent soft tissue contrast and multiplanar images when compared to other musculoskeletal imaging modalities. MRI has the added advantage of evaluating the internal architecture and surface of the menisci and ligaments.[1,2,3,4]

MR evaluation of menisci and ligaments has resulted in decreased morbidity and costs associated with negative arthroscopic examinations. It is also helpful in preoperative planning and selection of patients for surgery.[2,3]

Aims and Objectives

1. To study the demographic profile of patients presenting with internal derangement of knee.
2. To identify the various ligament and meniscal injuries causing internal derangement of knee.
3. To describe the MRI features of the ligament and meniscal injuries.

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MATERIALS AND METHODS

This study was undertaken from January 2016 to mid-December 2017 in the Department of Radiodiagnosis, MVJ Medical College and Research Hospital, Hoskote. The study population consisted of 108 patients with internal derangement of knee who underwent MRI of knee. Ethics committee clearance and informed consent were obtained.

All patients referred to the Department of Radiodiagnosis for MRI knee with clinical suspicion of internal derangement of knee or history of twisting injury to the knee with knee pain were included in the study. The exclusion criteria were patients with negative MRI, joint disease like rheumatoid arthritis, degenerative joint disease, septic arthritis, previous knee surgery and other general contradictions to MR imaging.

All the MRI scans of the knee in this study were performed using Siemens Magnetom Essenza (A Tim+Dot system) MR machine with a 1.5 tesla field strength magnet using a flex coil.

The patient was placed in supine position with the knee in either neutral position or 10 to 15 degrees of external rotation. Initial localisers were obtained in the axial plane through the patellofemoral joint, which was used for subsequent sagittal and coronal image planning.

The sequences used in performing the MR scans were T1 sagittal, T2 sagittal, coronal and axial, PD FS sagittal and axial and STIR coronal. The slice thickness was 3 mm. No contrast agent was given.

The cruciate ligaments and menisci were primarily assessed in the sagittal plane with coronal and axial images used for secondary confirmation of pathology. The collateral ligaments were primarily assessed on the coronal and axial planes.

The Ligamentous and Meniscal Injuries were Evaluated and Graded as Follows-

The anterior and posterior cruciate ligaments were considered normal, if they were visualised as a continuous low signal intensity bands on both coronal and sagittal images.

Cruciate ligament injuries were classified into sprain, partial surface tear, interstitial or intrasubstance tear, complete tear and avulsion injuries. Complete tears were subclassified based on the location of the tear into proximal, middle or distal third or as near the femoral or tibial attachment sites.

Cruciate ligament sprain was diagnosed when the ligament appeared hyperintense without distortion of individual fibres or ligament laxity.

Interstitial or intrasubstance cruciate ligament tear was diagnosed when the ligament appeared hyperintense with bowing, distortion of individual fibres or presence of focus of increased signal intensity within the ligament substance.

Complete cruciate ligament tear was diagnosed when there was discontinuity in the ligament with abnormal ligament course and signal intensity.

Focal or globular intrameniscal high signal intensity was considered MR grade 1 signal intensity. Horizontal, linear intrameniscal high signal was considered MR grade 2 signal intensity. Both grade 1 and 2 signal changes do not show extension to the articular surface and represent mucinous degeneration.

Intrameniscal high signal intensity extending up to the articular surface was considered as grade 3 signal change. Meniscal tear was diagnosed when grade 3 signal change was present.

Meniscal tears were classified into flap, horizontal, radial, vertical, bucket handle and complex tears based on cross-sectional and surface patterns.

Injuries of the collateral ligaments were classified into sprains, partial tears, complete tears and avulsion injuries.

RESULTS

Age in Years	Male	Female	Total	Percentage
<20	5	2	7	6.5
21-30	39	6	45	41.6
31-40	32	5	37	34.2
41-50	8	3	11	10.2
>50	6	2	8	7.4
	90 (83.4%)	18 (16.6%)	108	

Table 1. Age and Sex Distribution of Patients

MRI Findings	Number of Cases	Percentage
ACL injury	90	83.3
PCL injury	16	14.8
Medial meniscus tear	40	37
Lateral meniscus tear	18	16.6
MCL injury	17	15.7
LCL injury	14	13

Table 2. Ligament and Meniscal Injuries

ACL Injury Type		Number (90 Cases)		Percentage
Complete tear	Femoral site	21	52	57.7
	Proximal third	25		
	Middle third	4		
	Distal third	2		
	Tibial site	0		
Partial surface tear		4		4.4
Interstitial/intrasubstance tear		18		20
Avulsion fracture	Femoral site	0	6	6.6
	Tibial site	6		
Sprain		10		11.1

Table 3. Types of Anterior Cruciate Ligament (ACL) Injury

PCL Injury Type		Number (16 Cases)		Percentage
Complete tear	Femoral site	0	4	25
	Proximal third	0		
	Middle third	3		
	Distal third	0		

	Tibial site	1		
Partial surface tear		4		25
Interstitial/intrasubstance tear		2		12.5
Avulsion fracture	Femoral site	0	3	18.7
	Tibial site	3		
Sprain		3		18.7

Table 4. Types of Posterior Cruciate Ligament (PCL) Injury

Type of Tear	Medial Meniscus (41 Tears)	Lateral Meniscus (19 Tears)	Total Number of Tears (60)	Percentage
Flap	15	6	21	35
Horizontal	9	3	12	20
Vertical	4	3	7	11.6
Radial	3	2	5	8.3
Bucket handle	6	0	6	10
Complex	4	5	9	15

Table 5. Types of Meniscal Tears

Note-

a. 40 patients had medial meniscal tears. One of the patients had 2 medial meniscal tears. Hence, totally, there are 41 medial meniscal tears.
b. Similarly, one of the patients had 2 lateral meniscal tears. Hence, in total, there are 19 tears in 18 patients.

Site	Flap	Horizontal	Vertical	Radial	Complex	Total	Percentage
Root	0	0	0	2	0	2	3.7
Anterior horn	0	1	1	1	1	4	7.4
Body	0	0	0	1	0	1	1.8
Posterior horn	18	4	6	1	7	36	66.6
Posterior horn + body	3	7	0	0	1	11	20.3
Total	**21**	**12**	**7**	**5**	**9**	**54**	

Table 6. Site and Type of Meniscal Tears

Type		Medial Collateral Ligament (MCL - 17 Cases)	Lateral Collateral Ligament (LCL - 14 Cases)	% (MCL)	% (LCL)
Complete tear		7	0	41.1	0
Partial tear		0	4	0	28.5
Avulsion fracture	Femoral site	1	0	5.9	21.5
	Tibial/fibular site	0	3		
Sprain		9	7	53	50

Table 7. Type of Collateral Ligament Injury

Composite Injury	Number of Cases
ACL + MM	22
ACL + LM	10
ACL + MM + LM	6
ACL + PCL	9
ACL + PCL + MM	1
ACL + PCL + LM	0
PCL + MM	2
PCL + LM	0
MM + LM	0

Table 8. Composite Injuries

MRI Findings	Number of Cases
Parameniscal cyst	4
Baker's cyst	7
Bursitis	5
Bone contusion	46
Fracture	17
Joint effusion	98
Lipohaemarthrosis	5
Lipoma arborescens	1

Table 9. Additional MRI Findings

As shown in Table 1, the study population consisted of 108 patients comprising of 90 males and 18 females. The right knee was injured in 60 patients and the left knee in 48 patients. The age of the patients ranged from 16 to 67 years. Majority of the patients belonged to the age group of 21-30 years constituting about 41% of the total study population.

The common modes of injury were twisting injury to the knee during self-fall followed by road traffic accidents.

As shown in Table 2, anterior cruciate ligament injury was the commonest followed by medial and lateral meniscus tears. As shown in Table 3, the commonest type of anterior cruciate ligament injury was complete ligament tear at its proximal third and femoral attachment sites. Complete and partial tears of the posterior cruciate ligament were seen in equal number as shown in Table 4.

Flap tear was the commonest type of meniscal tear and medial meniscus was affected the most as shown in Table 5. Posterior horn of the meniscus was the commonest tear site as shown in Table 6.

The collateral ligaments were sprained in the majority of the cases as depicted in Table 7. The predominant pattern

of composite injury was ACL + MM injury followed by ACL + LM injury as shown in Table 8.

Parameniscal cysts were associated with horizontal meniscal tears. Majority of the cases demonstrated joint effusion and bone contusions. One of the patients had lipoma arborescens. Baker's cysts and bursitis were the other findings as shown in Table 9.

Figure 1. PD FS Sagittal Image Demonstrating Complete Tear of the Anterior Cruciate Ligament at its Proximal Third with Posterolateral Tibial Condyle Contusion, Joint Effusion and Popliteus Muscle Strain

Figure 2. PD FS Sagittal Image Demonstrating Interstitial Tear of the Anterior Cruciate Ligament

Figure 3. PD FS Sagittal Image Demonstrating Lateral Femoral Notch Sign in a Case with ACL Tear

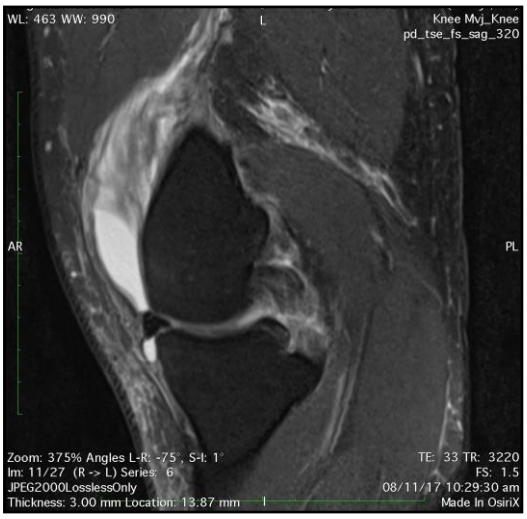

Figure 4. PD FS Sagittal Image Demonstrating Complete Tear of the Posterior Cruciate Ligament at its Middle Third with Joint Effusion

Figure 5. PD FS Sagittal Image Demonstrating Displaced Avulsion Fracture at the Tibial Attachment Site of the Posterior Cruciate Ligament with Adjacent Bone Contusion

Figure 6. PD FS Sagittal Image Demonstrating Inferior Surface Flap Tear of the Posterior Horn of the Medial Meniscus

Figure 7. PD FS Sagittal Image Demonstrating "Double PCL Sign" in a Case of Bucket-Handle Tear of the Medial Meniscus

Figure 8. PD FS Sagittal Image Demonstrating Horizontal Tear of the Posterior Horn of the Medial Meniscus with a Parameniscal Cyst

Figure 9. PD FS Sagittal Image Demonstrating Peripheral Vertical Tear of the Posterior Horn of the Medial Meniscus

Figure 10. STIR Coronal Image Demonstrating Complete Tear of the Medial Collateral Ligament at its Proximal Third with Joint Effusion

Figure 11. STIR Coronal Image Demonstrating Displaced Avulsion Fracture of the Fibular Head at the Insertion of Lateral Collateral Ligament

DISCUSSION

In our study of 108 patients with internal derangement of the knee, majority was males and the commonest age group was 21-30 years. Our findings correlate with the study of Majewski M. et al[5] on 17,397 patients with 19,530 sport injuries over a 10-year period of time. In that study, 6434 patients (37%) had 7769 injuries (39.8%) related to the knee joint. 68.1% of those patients were men and 31.6% were women. Almost, 50% of the patients were between the ages of 20-29 (43.1%) at the time of injury. Although, internal derangement of knee can occur at any age. They are common in younger people presenting with knee symptoms than in old age where the cause for knee symptoms is usually degenerative.

In our study, ligamentous injury was commoner than meniscal injury. Among the ligament injuries, ACL was the most commonly injured (83% of the patients) followed by medial collateral ligament and PCL injuries. Overall, medial meniscal tear was the second commonest type of injury seen in 37% of the patients.

Cruciate Ligament Injuries- The commonest type of ACL injury was complete tear at its proximal third (Figure 1), followed by intrasubstance/interstitial tears (Figure 2), sprains and avulsion injuries. This correlates with Prince et al[6] findings of increased incidence of complete ACL tears in skeletally mature patients and partial tears being commoner in skeletally immature patients. Avulsion injuries were seen at the tibial attachment site accounting for around 6% of the ACL injuries. This correlates with Stoller et al[3] finding of avulsions of the tibial intercondylar eminence in 5% of the patients. ACL injuries were commonly associated with medial meniscal tears, medial collateral ligament injury, lateral femoral notch sign (Figure 3) and posterolateral tibial plateau contusions. These findings correlated with the findings in the studies of Berquist TH et al,[7] O' Donoghue DH et al,[8] Rubin et al[9] and Remer et al.[10,11,12]

PCL injury was uncommon and was found in 14% of the patients. Among these, complete (Figure 4) and partial tears accounted for 50% of the PCL injuries. There were 3 cases of avulsion fractures (Figure 5) at the tibial attachment site of PCL. These findings correlated with the study of Gupta R et al.[13]

Meniscal Injuries- The medial meniscus was the most commonly injured meniscus. Flap tear was the commonest type of tear in both the menisci. Inferior surface flap tear (Figure 6) of the posterior horn was the commonest type of flap tear. Six cases of bucket-handle tear (Figure 7) of the medial meniscus were noted. These cases demonstrated the absent bow-tie, double anterior horn and double PCL signs on sagittal images. Nine cases of horizontal tears (Figure 8) were seen and four of these cases were associated with parameniscal cysts. Vertical tears (Figure 9) were commonly seen in the periphery of the posterior horns. Five cases of radial tears were noted. Of the 5 cases, 2 cases were displaced root tears, 1 each was noted at the anterior horn-body junction, midbody and posterior horn-body junction, respectively.

Gupta R et al[13] and Singh et al[14] also reported increased incidence of medial meniscal tears as compared to lateral meniscal tears. Stoller et al[3] also reported flap tears as the most common meniscal tear type.

Collateral Ligament Injuries- The collateral ligaments were sprained in the majority of the cases and were always associated with cruciate ligament injury.[3,8] Complete tears of the MCL (Figure 10) were the second commonest collateral ligament injury. Three cases of avulsion fractures (Figure 11) of the fibular head at the insertion of LCL were noted.

Bone Contusions and Fractures- Fractures with intraarticular extensions like tibial intercondylar eminence fractures were associated with lipohaemarthrosis. Haemarthrosis with irregularity of the posterior aspect of the Hoffa's fat pad were seen in majority of the cases.

Bone bruises were commonly found in the femoral and tibial condyle. Posterolateral tibial condyle was the commonest site of bone contusion.

ACL tears are associated with lateral femoral condyle and posterolateral tibial plateau contusions.[3,15] Segond fracture and avulsion fracture of the lateral tibial condyle at the insertion of the LCL is associated with ACL tears.[3,16,17,18,19] Tibial spine avulsions are uncommon, but specific for ACL injury.[3,18]

Anterolateral tibial condyle and posterolateral femoral condyle bone contusions are seen in patients with history of forced posterior displacement of the tibia in a flexed knee.[3,20] Anterior tibial plateau and anterior aspect of the femoral condyle bone contusions are seen in hyperextension injuries. An avulsion fracture of the medial tibial plateau associated with the deep portion of the MCL is called reverse Segond fracture.[3,21] The reverse Segond fracture is seen in cases with PCL rupture and peripheral medial meniscal tears. Avulsion fracture of the posterosuperior apex of the fibular styloid process, also known as arcuate sign is associated with PCL injury.[3]

Cartilage Injuries- FS PD-FSE sequences are sensitive for demonstrating cartilage injuries. FS PD-FSE images are sensitive to chondral fractures, flaps and osteochondral trauma by demonstrating the extent and location of fluid extension across the fracture segment.[3]

In osteochondral fractures, there is injury to the articular cartilage and the subchondral bone, whereas in chondral fractures, there is trauma to only the articular cartilage. Osteochondral fractures are associated with trauma, including direct injury, ligament ruptures and patellar dislocations. In adults, the articular cartilage is thought to tear at the junction between the calcified and uncalcified zones. In younger patients, the skeleton is immature with no calcified zone and the shearing forces are transmitted directly to subchondral bone producing an osteochondral fracture. Osteochondral fractures are most commonly seen in adolescents and are thought to represent a form of osteochondritis dissecans.[3,22]

Potter et al[23] found in their study of 42 knees in 40 patients with acute, isolated ACL injury that all patients sustained a cartilage injury at the time of initial impact with subsequent longitudinal chondral degradation in compartments unaffected by the initial "bone bruise."

CONCLUSION

Young adults are the most commonly injured population. Anterior cruciate ligament and medial meniscus are the most frequently injured structures.

MRI is a noninvasive, non-ionising diagnostic modality, which gives adequate information about the surface and intrasubstance abnormality of the ligaments and menisci.

MRI can diagnose interstitial or intrasubstance tears of the cruciate ligaments, which can be missed on arthroscopy.

MRI description of closed meniscal tears can guide the orthopaedician during arthroscopy as these tears are usually missed unless they are probed.

MRI can describe the morphology and location of meniscal tears, which can help in choosing between primary meniscal repair and partial meniscectomy.

Abbreviations

ACL - anterior cruciate ligament; PCL - posterior cruciate ligament; MM - medial meniscus; LM - lateral meniscus; MCL - medial collateral ligament; LCL - lateral collateral ligament.

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