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Original Research Paper

Radio-Diagnosis

SPECTRUM OF INJURIES ON MRI IN TRAUMATIC KNEE JOINT

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ABSTRACT Background and objectives: - MRI is an excellent technique for evaluation of soft tissue injuries, ligaments, cartilage, and capsule with bone contusion. It is a noninvasive and radiation free imaging modality. This study aimed to evaluate the spectrum of grading /severity of knee injuries on MRI. Methodology: A total 60 patients who had knee trauma referred from Orthopedic department to Radiodiagnosis department for MRI examination. This study was observational study and included 60 patients who full filled inclusion criteria during the study period from Feb 2018 to Jan 2019 and underwent MRI using an 8- channel dedicated knee coil using GE 1.5 T Signal MR monitor. Results: In our study, knee injuries most commonly present in male (71.66%) as compared to female (28.33%). The maximum numbers of patients in our study were either between 18 to 30 years of age or second largest group of patients belonged to the age group between 51-80 years. There were 19 males and 7 females in 18 to 30 years age group and 9 males and 7 females in 51-80 years age group. The male to female ratio in our study 2.5:1 and the mean age group 34.83 years in male and 41 years in female. The overall mean age of 60 patients was 36.5 ± 13.64 . The right knee joint was commonly injured in our study (65%). The most common mode of injuries was twist in young age group followed by history of fall in old age group population. In our study most common injury was ACL tear (66.66%) followed by medial meniscus tear (40%), lateral meniscus tear (11.66%), PCL tear (10%), MCL tear (6.66%) and LCL tear (5%). Mid-substance tear was most common in both ACL and PCL tear. Grade III signal intensity was commonly present in menisci with 66.66% and 57.14% involvement of medial and lateral meniscus respectively. Horizontal meniscal tear was the most common injury in both menisci. The posterior horn was most involved in both menisci. Additional findings noted along with ligamentous and meniscal injuries were bone contusion (78.12%), fractures (21.87%), muscle strain (5 %), tendon sprain (1.6 %), backer's cysts (5 %) and peri meniscal cyst (1.6 %). Conclusion: MRI is useful effective tool for evaluation of ligamentous injuries, meniscal injuries, articular cartilage pathology, tendon, capsule, retinacular injuries and bone injuries of knee joint because of excellent contrast resolution and multiplanar capabilities.

KEYWORDS : Trauma, Knee, MR imaging, ACL, PCL, Medial meniscus, MCL.

INTRODUCTION

The knee is the largest joint in the body. It is a complex type of synovial joint and due to the lack of bony support, stability and mobility of the joint is highly dependent on its supporting ligamentous structures^{1,2}, therefore injuries of ligaments and menisci are extremely common especially in active young adults, athletes & road traffic accidents.³

Traumatic knee joint is a significant cause of morbidity in both young and old individuals³. Joint injury has been recognized as a potent risk factor for the onset of osteoarthritis.⁴ An accurate diagnosis regarding the type and extent of injuries is essential for early operative as well as non-operative treatment. This requires an accurate clinical history, a thorough physical examination and complementary diagnostic tools with the availability of improved surgical options, accurate imaging of the knee becomes even more imperative.³

MR imaging had been used since 1980 in clinical practice for evaluating internal knee derangements.³ The role of MRI has steadily increased and has been shown to be an effective tool for definition and characterization of knee pathology. MRI is excellent for evaluating the musculoskeletal system for soft tissue injuries and bony abnormalities after trauma⁵ as it has excellent soft tissue resolution and multiplanar imaging capability, making it superior to other imaging techniques in the evaluation of traumatic injuries of the knee joint. MRI has been approved best diagnostic imaging for knee joint and doesn't involve the use of ionizing radiation.^{6,7} The accuracy of MRI is very high in diagnosing knee injuries and has as sensitivity of 80% to 100%. MRI is also being used for pre and postoperative evaluation of knee joint.

MRI can accurately detect, localize, and characterize various internal derangements of the knee joint and help in arriving at a correct anatomical diagnosis thereby guiding further management of the patient.⁶ Musculotendinous injuries and associated structural distortion are evaluated in all three planes i.e., axial, coronal, and sagittal images.

Complete evaluation of all the internal structures of the knee was not possible with other modalities like conventional radiography, arthrography, ultrasonography, and computed tomography. Even with arthroscopy, injuries such as peripheral meniscus tears, inferior surface tears and osteochondritis dissecans without articular damage are most often not detected³. With the advent of MR imaging, a new diagnosis was described: occult bone injury or occult intraosseous fracture.

The mostly used diagnostic modalities arthroscopy and MRI for assessment of joint injury.³ The MRI is non-invasive diagnostic tools, proved reliable, safe and provides better advantage over diagnostic arthroscopy.⁶ Arthroscopy is gold standard test for diagnosis of intra-articular pathology of knee joint, but it is an invasive and can cause complications.¹⁸ MRI has also been cost effective tools by reducing unnecessary arthroscopic interventions.

AIMS AND OBJECTIVES

 To evaluate the spectrum and incidence of the various ligaments and meniscal injuries of post-traumatic knee joint.

 To evaluate the grading/severity of the various ligaments and meniscal injuries of post traumatic knee joint.

CASE STUDY

Study area: This study was conducted in Max Super Speciality Hospital, Phase-6, Mohali, Punjab. The subjects were selected from the patients visiting the department of orthopedic and referred to the radio – diagnosis department. **Study population:** Patient of more than 18 years and less than 80 years with either sex, having traumatic knee joint injuries, which is clinically diagnosed, was included in the study.

Selection criteria:

Inclusion criteria: All patients of different age groups (18-80 years) presenting with history of trauma to the knee joint, who were sent for Magnetic Resonance Imaging of the knee.

Exclusion criteria:

- All patients who did not give consent to be a part of the study.
- Post operative cases.
- Congenital anomalies, degenerative changes of knee joint e.g., Osteoarthritis, infection, and neoplasm.
- Patients with ferromagnetic implants, pacemakers and aneurysm clips and any other contraindications for MRI.
- Patients with major injuries like liver / splenic rupture and flail chest and patients with Unstable vital parameters specially in the setting of trauma.

Sample size: Considering the last year statistics in the department of Radio-diagnosis Max Superspeciality Hospital Mohali, 70 cases of traumatic knee joint came and considering dropouts.

 $S = (Z)^{2}(p)(q)/(d)^{2}$ = 1.96x1.96x0.96x0.04/0.05x0.05

= 60

To estimate this proportion with a 95% confidence interval of proportion & margin of error as 5% the sample calculated using the formula, where S is the sample size, z is the value for the selected alpha level, e.g., 1.96 for (0.05) i.e., at 95 % confidence level. p is the estimated proportion of an attribute that is present in the population. q is 1 -p. d is the acceptable margin of error for proportion being (we have taken 5%).

Hence, minimum of 60 patients having traumatic knee joint clinically diagnosed were included in the study.

Study design: Prospective observational study.

Study intervention: None

Study duration: One year (Feb.2018 to Jan.2019) after institutional ethical committee approval.

Methodology

This observation study was conducted in 60 traumatic knee joint patients who came to Department of Radiodiagnosis at Max Superspeciality Hospital, Mohali, underwent GE 1.5 T Signa MR monitor.

Statistical analysis: The statistical analysis was carried out using IBM SPSS (Statistical Package for Social Sciences) statistical version 21. The analysis includes frequency table, bar, pie chart, association of variables based on Chi-square test and if any cell frequency is <5, then Yates corrections is used for 2×2 contingency table or method pooling and Fischer exact test is used (for higher order than 2×2 table) and proportion compare using the Z-proportion test. Normality of data was checked by Kolmogorov–Smirnov tests of normality. All quantitative variables were estimated using measures of central location (mean and median) and measures of dispersion (standard deviation). All statistical tests were seen at two-tailed level of significance ($p \le 0.01$ and $p \le 0.05$)

RESULT

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This observational study was carried out under the Department of Radiodiagnosis, Max Superspeciality Hospital from February 2018 to January 2019. A total of 60 patients who fulfilled the inclusion criteria of having traumatic knee injury during the study period were enrolled.

The data obtained was coded and entered Microsoft Excel Worksheet (Annexure III). The data was analyzed, and the final observations were tabulated as below in rate, ratio, proportions, and percentages.

Table 1. Age distribution

Age in years	Number	Percentage (%)
18-30	26	43.33
31-40	11	18.33
41-50	7	11.66
51-80	16	26.66
Total	60	100
Mean Age	36.5 year	
Standard	13.64	
Devigtion		

Table 2. Gender wise distribution

Sex	Number	Percentage (%)
Male	43	71.66
Female	17	28.33

Table 3. Side distribution

Side	Number	Percentage (%)
Right	39	65
Left	21	35

Table 4. Mode of injury

Mode of Injury	Number	Percentage (%)
FALL	27	45
TWIST	19	31.66
RTA	14	23.33

Table 5. Spectrum of MRI findings

MRI finding	Number	Percentage
ACL tear	40	66.66
PCL tear	6	10
MM tear	24	40
LM tear	7	11.66
MCL tear	4	6.66
LCL tear	3	5
Joint Effusion	50	83.33
Osseous/	32	53.33
Osteochondral		
Lesion		

Table 6. Age wise distribution of ligament and meniscal injuries

Āge	ACL	PCL	MM	LM	MCL	LCL
category	Injury	Injury	Injury	Injury	Injury	Injury
18-30	17	1	11	2	0	0
Years						
31-40	7	1	2	1	1	1
Years						
41-50	6	2	3	1	3	1
years						
51-80	10	2	8	3	0	1
Years		[

Table 7. Anterior & Posterior cruciate ligament tear

TEAR	ACL tear	PCL tear		
Absent	20(33.33%)	54(90%)		
Present	40(60.66%)	6(10%)		
Types of ACL&PCL tear				
Partial	12(30%)	3(50%)		
Complete	28(70%)	3(50%)		
T 11.0 M 1.10 T				

Table 8. Medial & Lateral meniscus tear

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TEAR	MM	LM
Absent	36(60%)	53(88.33%)
Present	24(40%)	7(11.66%)
Grading of meniscal tear		
Grade I	3(12.50%)	1(14.28%)
Grade II	4(16.66%)	1(14.28%)
Grade III	16(66.66%)	4(57.14%)
Grade IV	1(4.16%)	1(14.2%)

Table 8.1. Type of medial & lateral meniscus tears

Types of meniscal tears	MM	LM
Horizontal tear	14(58.33%)	3(42.85%)
Longitudinal tear	4(16.66%)	1(14.28%)
Vertical tear	2(8.33%)	-
Radial tear	1(4.1%)	1(14.28%)
Root tear	1(4.1%)	1(14.28%)
Bucket handle type	1(4.1%)	-
Complex tear	1(4.1%)	1(14.28%)

Table 8.2. Location of medial &Lateral meniscus tears

Location of meniscus tears	MM	LM
Posterior horn	16(66.66)	4(57.14%)
Posterior horn with Body	5(20.83)	0
Body	0	1(14.28%)
Anterior horn with Body	1(4.16%)	0
Anterior horn	1(4.16%)	2(28.57%)
Complete meniscus	1(4.16%)	0

Table 9. Medial& Lateral collateral ligament tear

TEAR	MCL	LCL
Absent	56(93.33%)	57(95%)
Present	4(6.66%0	3
Grade of MCL tear		
Grade I	3(75%)	3(100%)
Grade II	0	0
Grade III	1(25%)	0

Table 10. Osseous / Osteochondral lesions

Osseous/ Osteochondral Lesions	Number	Percentage (%)
Absent	28	46.66
Present	32	53.33
Type of osseous lesion		
Contusion	25	78.12
Fracture with Contusion	7	21.87

Cases:







Fig. 1. A PDFS sagittal image shows low grade partial ACL tear(arrow).

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B. PDFS sagittal image show high grade partial ACL tear (notched arrow).

C. PDFS sagittal image shows complete mid substance ACL tear(chevron).

D.PDFS sagittal image shows mucoid degeneration (celery stalk appearance) of ACL ligament(star).



Fig. 2. A PDFS sagittal image shows horizontal tear in posterior horn of medial meniscus (arrow).

B. PDFS sagittal image show Vertical longitudinal tear in posterior horn of medial meniscus (notched arrow).

C. PDFS sagittal image shows flipped meniscus tear of medial meniscus/Bucket handle tear (flipped arrow)

D.GRE sagittal image shows macerated posterior horn of medial meniscus/Complex tear (Chevron)



Fig.3. (A) PDFS Cor image shows Grade III signal in medial collateral ligament /Complete tear(arrow).
(B) PDFS Cor image shows Grade I hyperintense signal in femoral attachment of lateral collateral ligament (chevron).

DISCUSSION

The knee joint injuries cause significant morbidity affecting both young and old individuals. Knee injury management requires a comprehensive clinical history adjuvant with a thorough physical examination and a complementary imaging tool.

Conventionally the injuries around the knee joint are assessed clinically and then subjected to imaging. The knee joint can be imaged with many different imaging modalities: Radiograph, Ultrasound, Bone scintigraphy, CT scan, Arthroscopy & MRI. Since the 1990 s MRI has been the modality of choice for imaging the internal derangements of the knee joint⁸. MRI is being used both as pre- and post-operative evaluative method³.

Recent development of newer sequences of MRI, along with improved SNR (signal to noise ratio), higher resolution, reduced artifacts and shorter imaging times has accentuated the diagnostic accuracy. The traditional algorithm for diagnosis of knee joint pathology has been changed using MRI. Because of MRI it is possible to visualize into the injured knee noninvasively hence evading invasive procedures and additional morbidity⁶. The sensitivity of injuries to ACL, PCL, MM and LM has been observed to be as high as 94.59%, 100%, 68.42% and 69.23% respectively and the specificity of injuries to ACL, PCL, MM and LM as 80.00%, 100%, 86.66% and 94.10% respectively⁷⁰

This one-year observational case series was done to study the spectrum of injuries as seen as on MRI in traumatic knee joint in the Department of Radio-diagnosis of Max Superspeciality Hospital, Phase -VI Mohali, Punjab (225 bed corporate hospital).

A total of 60 patients who fulfilled the selection criteria of having a clinically diagnosis of a traumatic knee injury during the study period from February 2018 to January 2019 were included. They underwent MRI 1.5 Tesla GE Signa Monitor using an 8-channel dedicated knee coil at this hospital.

The number of patients in previous study of similar nature has been 50 cases each in Madurwas AU et al⁹ and Naresh Nikhil B L et al¹⁰, 100 cases in Umap RA et al¹¹. In that respect 60 cases in present study seems reasonable for this kind of analysis.

In this group of 60 patients, the age distribution was from 18 to 80 years in which 43(71.66%) patients were male and 17 females (28.33%). The maximum number of patients in our study were either between 18 to 30 years of age or second largest group belonged to the age group between 51-80 years. There were 19 males and 7 females in 18 to 30-year age group and 9 males and 7 females in 51-80 years. The male to female ratio in present study 2.5:1. Umap RA¹¹ and Madurwar AU et al⁹et al in their study on 100 and 50 patients observed male and female ratio as 4:1 and 5.2:1 ratio respectively.

As we had almost equal ratio of male and females in 51-80year age group. This might have been cause of low male and female ratio in present study.

The mean age of males in our study was 34.83 year and it was 41 years mean age of females. The total group of 60 overall mean age was 36.5 ± 13.64 years.

The usual cause of 18-30-year age group, as per literature, was sports related activities and traffic accident while 51-80year age group had history of fall as most common mode of injury because of comorbidities and imbalance to posture.

In contrast to Naresh Nikhil B L et al¹⁰ who observed 60% incidence of left knee, others like Singh JP et al¹² and our present study observed high incidence of right knee involvement, the incidences being 53.76% and 65% respectively.

The probable reason behind this predominance of right knee involvement could be that majority right-handedness and is mostly injured during sports activities.

In the present study ACL injuries (66.6%) were most common injury followed by Medial meniscus injury (40%), Lateral meniscus injury (11.66%), PCL injures (10%), MCL injury (6.66%) and LCL injury (5%). Thus our observations matches the contemporary literature and the studies done by Umap RA et al¹¹, Madurwar AU et al⁹ and Naresh Nikhil B L et al¹⁰

The most common injury in the all age group was ACL injury, followed by medial meniscus injury. No other study has

provided age wise distribution of ligamentous and meniscal injury.

Anterior cruciate ligament (ACL) injuries: -

In our study the ACL tear was most injured ligament and was seen in 40 out of 60 patients (66.66%).

	Current	Umap RA et	Madurwa	Naresh	Singh
	study	al 11 2018	r AU Et	Nikhil B L	JP et al
	(n=60)	(n=100)	al9	et al 10	12 2004
			2017(n=5	2015(n=5	(n=173)
			0)	0)	
ACL injuries	66.66%	76%	76%	66%	45.08%

In our study of 40 (66.66%) cases of ACL tears, 70% were complete tear and 30% were partial tear. Similar results were observed in the study conducted by Madurwar AU et al³ and Naresh Nikhil B L et al¹⁰

However low incidence of ACL tear was observed in another study by Singh JP et al¹² which was not supported with any explanation in their study.

Out of 40 patients of ACL tear, 20 patients (50.00%) had midsubstance tear, 10 patients (25.00%) had tear at femoral attachment, 8 patients (20.00%) had tear at tibial attachment and 2 patients (5%) had tibial avulsion. Mid substance tear was the most common ACL tear. The same result was derived by the studies conducted by Naresh Nikhil B L et al¹⁰ and Singh JP et al¹²

In our study ACL tear was most commonly injured, owing to the thin fibers of ACL as compared to thick fibrous PCL

Posterior cruciate ligament:

	Current study (n=60)	Umap RA et all1 2018 (n=100)	Madurwar AU Et al9 2017(n=50)	Naresh Nikhil B L et all0 2015(n=5 0)	Singh JP et al12 2004 (n=173)
PCL Injuries	10%	15%	6%	12%	5.78%

In the present study, posterior cruciate ligament tear was seen in 6 patients (10%).

Partial tear of PCL was seen in 3 patients and complete tear of PCL was seen in 3 patients. The results of PCL tear injury from our study derive same proportional distribution as the study conducted by Umap RA et al¹¹.

Out of the PCL tear in 6 patients, mid substance tear was found in 4 patients and 1 tibial and femoral attachment tear was noted, making the mid substance tear the most common type of PCL tear. Similar results were found in the study conducted by Umap RA et al¹¹.

The posterior cruciate ligament injury is less common as compared to the ACL because it is stronger and thicker.

Meniscal injuries: -

In the current study there is preponderance of medial meniscal tear (40%) over lateral meniscal tears (11.66%).

Meniscal injuries	Current study	Umap RA et	Madurwar et al	Jeevika MU et	Singh JP et all2
-	(n=100)	alll	study9	all3	2004(n=
		2018(n	2017	2017(n=4	173)
		=100)	(n=50)	3)	
Medial	40%	38%	34%	46.55%	38.23%
meniscus					
injury					
Lateral	11.66%	26%	22%	37.2%	29.41%
meniscus					
injury					
In present study Grade III and horizontal tear are most					

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common in both medial and lateral meniscal tear. Similar results were found in studies conducted by Umap R A et al^{11} , Singh JP et al^{12} , Jeevika M U et al^{13} and D S Shetty et al^{14} .

In present study, posterior horn tear is most common in both medial and lateral meniscal tear. The results of present study corresponded with the studies conducted by Umap R A et al¹¹, Jeevika M U et al¹³ and Singh JP et al¹²

The degeneration and tears of menisci represented as high signal intensity were due to imbibed synovial fluid. These tears are better seen on short TE of T2 / PDFS and GRE images. This has been explained by Stoller et al¹⁵ in their study as the interaction of synovial fluid with large macromolecules in menisci slows rotational rate of protons and shortens T1 and T2 values.

In current study, we found the T2* weighted GRE images to be better to detect meniscal tears compared to T2 FSE image, as supported by Rubin et al^{16} .

MM is most commonly injured as compared to LM because MM bears more compressive forces due to less mobility as it is peripherally attached to deep fibers of MCL and absorb 50% the shock.

Collateral ligaments injuries:

In the present study, MCL tear was seen in 4 patients (6.66 %) of which 3 patients had Grade I tear (sprain) and 1 had Grade 3 tear. LCL tear was seen in 3 patients (5 %) and all of them had Grade I tear (sprain). Grade I tear(sprain) was the most common type of injury in both medial (75%) and lateral collateral ligaments (100%). Out of 4 MCL injuries, 2 patients also had ACL tear and 2 patients had ACL tear as well as medial meniscus injury (O Donoghue triad).

Osseous and Osteochondral lesions:

Bone contusion was seen in 32 patients (53.33%) of which 7 patients (21.87%) also had bone fractures. Similar results were observed in the studies conducted by Umap RA et al¹¹.

In our study, bone contusion associated with ACL, PCL, medial meniscus and lateral injuries were present respectively in 57.5%, 50%, 58% and 57.14% patients. Medial meniscus injuries were most associated with bone contusion.

CONCLUSIONS

Magnetic resonance imaging characteristics of ligamentous and meniscal injuries in traumatic knee joint was studied and following conclusions were drawn: -

- The incidence of traumatic knee injury was more common in young and old population as sports related activities and traffic accidents are more prevalent in young population while tendency of fall due to comorbidities and imbalance of posture is more prevalent in old population.
- Traumatic knee injury was more common in males as males are more involved in outdoor activities and sports related activities thus more prone to injuries associated with them.
- Right knee injury was more common than left knee injury probably as most persons are right-handed thus there are more chances of injury to right knee in sports related activities.
- The most common ligamentous/meniscal injury was ACL followed by medial meniscus, lateral meniscus, and PCL. The least common ligament injuries were MCL and LCL injury.
- The ACL complete tear is more common as compared to partial ACL tear. The most common location of ACL tear was at mid substance.
- Most common medial meniscus injury was grade III tear with horizontal tear being the commonest type and posterior horn being the commonest location.

 Thus, MRI is useful effective tool for evaluation of ligamentous injuries, meniscal injuries, articular cartilage pathology, tendon, capsule, retinacular injuries and bone injuries of knee joint because of excellent contrast resolution and multiplanar capabilities.

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