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Original Research Article

Magnetic resonance imaging of post traumatic knee: injury pattern analysis in sports activities

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ABSTRACT

Background: Musculoskeletal injuries of knee are commonly encountered in sportsmen during sports activities. Magnetic resonance imaging (MRI) is the modality of choice for evaluation of traumatic knee injuries and arthroscopic interventions. By knowing the pattern and burden of surgically significant injuries in sportsmen, the artificial intelligence (AI) software may be developed accordingly so that surgically significant injuries may be identified by the young radiologists.
Methods: It was a retrospective study on MRI for knee injuries in sportsmen. The digital data from Radiology department at a zonal level hospital was analysed. The MRI findings were correlated with the arthroscopic records available. For surgically insignificant injuries, the literature was referred for the typical MRI findings of the injuries.
Results: Of 272 cases of MRI knee, 74.3% cases were detected to have acute traumatic injuries. Among various types of injuries found in this study, anterior cruciate ligament (ACL) tear (55.9%) was the commonest injury followed by medial meniscal tear (40%). 40 (19.8%) cases were found to have surgically significant MRI findings which were subsequently corroborated with knee arthroscopy.
Conclusions: Since majority of soft tissue injuries of knee constitute ACL and meniscal tears, the industries involved in developing AI software for soft tissue injuries of knee, should primarily focus on identification of ACL and meniscal injuries. The AI software may also be helpful for the young radiologists in early training days in MRI for knee injuries and may also help in big scale research projects of post traumatic MRI knees.

Keywords: Sportsmen, Knee injuries, MRI, AI

INTRODUCTION

Knee joint is stabilized by a complex arrangement of ligaments, menisci and tendons.[1] Knee injuries are one of the most common injuries during sports activity. In United states, a study on 6.6 million knee injuries over a period of 10 years, showed that 49.3% of knee injuries were related to sports or recreational activities and most of these were soft-tissue injuries.[2] Significant knee injuries lead to impaired knee function leading to decreased participation in sports activities and sometimes absenteeism from work. Clinical examination alone is not sufficient to diagnose the knee injuries with full confidence. Radiographs and computerized tomography (CT) scans are not adequate to diagnose the ligamental and meniscal injuries.[3] Due to excellent soft-tissue contrast resolution, MRI is the modality of choice for evaluation of traumatic injuries in knee. It is a non-invasive and radiation-free modality which allows evaluation of ligaments, menisci, cartilage, muscles as well as bones.[4] This provides access to a real "lesional mapping" of the knee. MRI has also been demonstrated

as a cost-effective technique by reducing unnecessary surgical and arthroscopic interventions.[5]

In recent years, many conservative, arthroscopic and surgical procedures have been available for the treatment of various soft tissue injuries in traumatic knee. In a study by Van et al 39% patients had positive MRI findings which required further evaluation by orthopaedic surgeon.[6] MRI imaging has high diagnostic accuracy for the post-traumatic knee injuries.[7] Present study gives an overview of various MRI findings in knee with injury sustained during sports activity. This study also helps in knowing the pattern and burden of surgically significant injuries during sports activity. It may boost the interest in developing AI software so that surgically significant injuries are identified by the young radiologists in early phase of MRI training. The AI software may become a useful tool in conducting large scale level research on post traumatic knee injuries.

METHODS

It was a retrospective study of MRI knee cases done between July 2017 to December 2019 at INHS Sanjivani, Kochi. For this purpose, the digital data stored in the department of radiology at a zonal level hospital in India, was retrieved and analysed. MRI knee for these cases had been done with 1.5 T Philips Achieva MRI scanner. In MRI protocols, the PD SPAIR in three orthogonal planes, T1 coronal, T2 sagittal and STIR coronal sequences had been performed in all cases (Table 1). MRI findings were correlated with the arthroscopic records available, and the MRI findings matched the imaging findings. For surgically insignificant injuries, the literature was referred for the typical MRI findings of the injuries.

Table 1: MRI protocol for evaluation of knee.

Sequences	Planes	Matrix	Slice thickness/ gap (mm)	FOV (cm)
PD SPAIR	Oblique sagittal, coronal, axial	260×253	3/0	14
T1	Coronal	332×225	3/0	14
T2 SPAIR	Oblique sag	292×244	3/0	14
STIR	Coronal	224×160	4/0	14

Inclusion criteria

Knee injuries sustained during sports activity were included in the study.

Exclusion criteria

Knee injuries not related to sports activity were excluded from the study.

Statistical analysis

The findings were tabulated and analysed using IBM SPSS (Statistical package for social studies) for windows 10 (version 23.0 GA). The categorical data was expressed as rates, proportions and percentages.

RESULTS

There were 272 clinical cases of knee injuries who underwent MRI knee. There were 235 males (86.40%) with a mean age of 30.5 year and 37 females (13.60%) a mean age of 21.1 year (Table 2). Right knee was involved in 134 (49.26%) cases and there were 138 (50.74%) cases of left knee injuries. Traumatic knee injuries on MRI were seen in 202 cases (Table 3). Of these, there were 180 (89.1%) males and 22 (10.9%) females. Of 202 cases, various soft tissue and bony injuries detected (Table 4).

Table 2: Gender and age wise distribution of clinical cases of knee injury, (n=272).

Variables	Males (%)	Females (%)
No. of cases (%)	235 (86.4)	37 (13.6)
Mean age (Years)	30.5	21.1

Table 3: Gender and age wise distribution of cases of knee injury detected on MRI, (n=202).

Variables	Males (%)	Females (%)
No. of cases	180 (89.1)	22 (10.9)

Table 4: Various soft tissue and bony injuries. ACL, PCL, medial collateral ligament (MCL), lateral collateral ligament (LCL), medial meniscus (MM), lateral meniscus (LM), (n=202).

Injuries	N	Percentage (%)
ACL	113	55.9
PCL	08	3.9
MCL	11	5.4
LCL	05	2.4
MM	81	40
LM	38	18.8
Patellar tendon	01	0.5
Chondromalacic changes	14	6.9
Osteochondral injury	04	1.9
Hemarthrosis	02	1
Moderate to severe joint effusion	09	4.4
Bony contusions	48	23.7
MM+LM	05	2.5
MM+ACL	28	13.9
LM + ACL	13	6.4
MM+LM+ACL	10	5
ACL+MCL+MM	02	1
ACL+MCL+LM	02	1
ACL+MCL	03	1.5
PCL	03	1.5

ACL and posterior cruciate ligament (PCL) tears were found in 113 (55.9%) and 8 (3.9%) cases respectively. Out of 113 cases of ACL tears, complete and partial ACL tears were seen in 77 (68.1%) and 36 (31.9%) cases respectively. Out of 77 complete ACL tears, there were femoral attachment site tears in 37 (48%) cases, mid substance tears in 36 (46.7%) and tibial attachments tears in 2 (2.6%) cases. In 02 (2.6%) cases, ACL was not visualized on MRI. Of 36 partial ACL tears, there were mid-substance tears in 22 (61.1%) cases, femoral attachment tears in 8 (22.2%) cases and tibial attachment tears in 6 (16.7%) cases.

Medial and lateral meniscal tears were seen in 81 (40%) and 38 (18.8%) cases respectively. Of 81 cases of medial meniscal injuries, posterior horn alone was involved in 41 (50.6%) cases. Out of 38 cases of lateral meniscal injuries, posterior horn alone was involved in 16 (19.7%) cases. In medial meniscus, the grade-1 and grade-2 hyperintensities were seen in 2 (2.5%) and 35 (43.2%) cases respectively. In lateral meniscus, the grade-1 and grade-2 hyperintensities were found in 4 (10.5%) and 11 (28.9%) cases respectively.

Horizontal tears were seen in 19 (23.4%) medial meniscal and 14 (3.7%) lateral meniscal injuries. Longitudinal vertical tears were found in 2 (2.5%) medial meniscal injuries and 3 (7.9%) lateral meniscal injuries. Complex tears were observed in 12 (14.8%) medial meniscal and 5 (13.1%) lateral meniscal injuries. Radial tears were found in 4 (4.9%) medial meniscal and 1 (2.6%) lateral meniscal injury. Bucket handle tears were noticed in 5 (6.2%) medial meniscal and 1 (2.6%) lateral meniscal injury. Posterior root tears were found in 2 (2.5%) medial meniscal and 1 (2.6%) lateral meniscal injury.

Medial collateral ligament (MCL) and lateral collateral ligament (LCL) tears of various grades were detected in 11 (5.4%) and 5 (2.4%) cases respectively (Figure 2). Grade-3 tear was seen in 1 case of MCL tear and 04 cases of LCL tears.

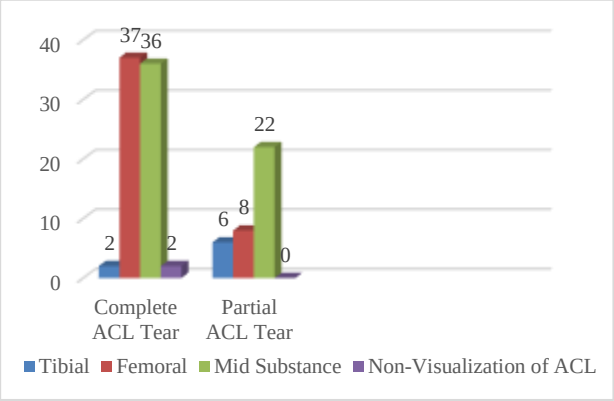

Figure 1: Number of ACL tear from tibial attachment site, femoral attachment site, mid-substance of ACL tear and non-visualization of ACL in cases of complete and partial ACL tear.

Of 202 cases, 48 (23.7%) cases had bony contusions. Of these, 26 (54.1%) bony contusions had involvement of lateral femoral and lateral tibial condyles (Figure 3). 14 (6.9%) cases had focal chondral injuries. Of these, 10 injuries were related to patella and 04 injuries were seen at articular surfaces of femoral and tibial condyles. Of 202 cases, 02 (1%) cases had hemarthrosis, and moderate to severe knee joint effusion was found in 09 (4.4%) cases. 63 (31.2%) cases had combination of multiple soft tissue injuries. The 111 (54.9%) cases had surgically significant injuries (Figure 4).

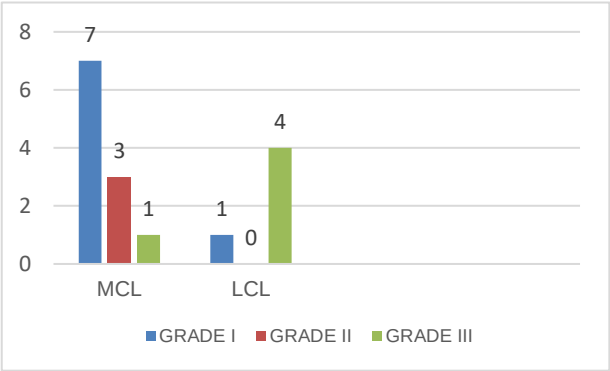

Figure 2: Grades of MCL and LCL injuries.

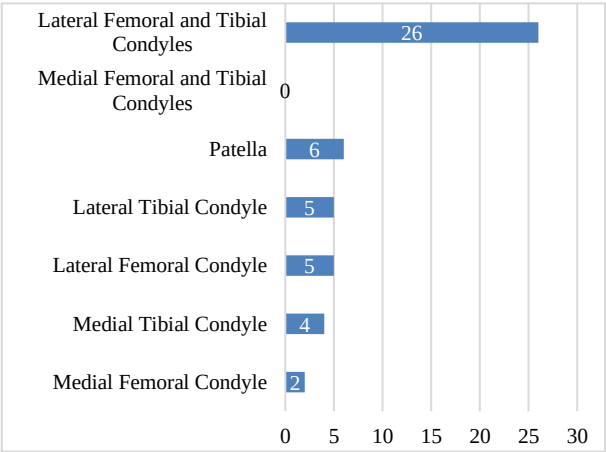

Figure 3: Location of bony contusions.

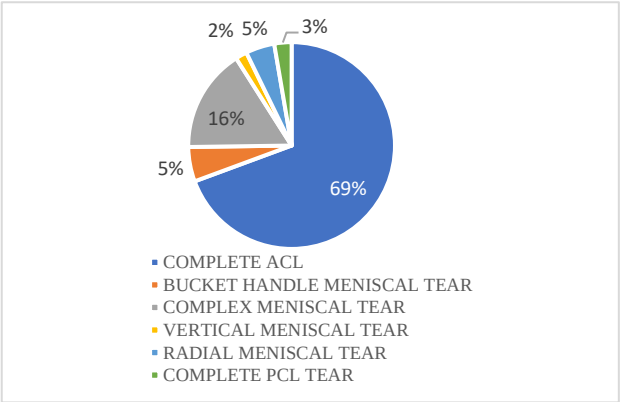

Figure 4: Surgically significant injuries.

DISCUSSION

Out of 272 cases, there were 235 males (86.40%) with a mean age of 30.5 year and 37 females (13.60%) a mean age of 36.1 year. A study done by Kulkarni showed more cases of involvement of males in knee injuries in sports-related activities.[8] In present study, there were 134 (49.26%) of right knee cases and 138 (50.74%) left knee cases. Mane et al also found that the right knee was more frequently involved than left knee in sports-related activities.[9] In a study by Madurwar et al on 50 knee trauma patients, there were 42 (76%) males and 8 (16%) females.[10] In a study by Shetty et al on 115 patients, there were 70 (60.86%) males and 45 (39.14%) females.[11]

Anterior cruciate ligament

ACL is the most commonly injured ligament in the knee and most often it requires surgical repair.[12] Present study (Table 4) showed the commonest finding in post-traumatic knee MRI was ACL tear (55.9%). Of all ACL tears, the complete and incomplete tears were seen in 68.1% and 31.9% respectively. In a study on 50 patients, Madurwar et al found 76% had ACL tear, and out of these, 79% had complete ACL tear and 21% had partial tear.[10] In a study by Rajesh et al 67% of the post traumatic Knee cases had ACL injury.[13] In present study, the commonest location of ACL tear was at midsubstance (51.3%), followed by femoral attachment tear (39.8%). 7% cases had tear at tibial attachment site (Figure 1). The findings of present study coincide with Berquist wherein the mid substance tear is the commonest finding followed by femoral and tibial attachment site tears.[12] Shetty et al reported 71.4% cases of mid-substance ACL tear.[11] Rajesh et al also found that the commonest site of tear was midsubstance (47.4%) followed by femoral (42.10%) and tibial (10.5%) attachment site tears.[13]

Posterior cruciate ligament

This study showed PCL tear in 2.9% cases. There were 03 complete tears and 05 partial PCL tears. Various studies showed the incidence of PCL tears in knee injuries as 6%, 4.4%, 15.1% and 5.78% respectively.[10,11,13,14]

Menisci

Present study showed 29.8% cases with a medial meniscus tear and 14% cases with a lateral meniscus tear. Shetty et al found medial meniscal tears were more common (36.7%) than lateral meniscal tears (17.3%).[11] Rajesh et al found the involvement of medial meniscus in 38% and lateral meniscus in 26%.[13] Posterior horn of medial meniscus was the most common site of meniscal injury followed by posterior horn of lateral meniscus. In present study, grade-II tear was the commonest finding in both menisci. Longitudinal horizontal tear was commonest, followed by complex meniscal tear, bucket-handle tear, radial tear, posterior root tear and longitudinal vertical tear. In this study, Table 5 shows the various types and pattern of meniscal injuries and Table 6 shows location of injury in meniscus. For medial meniscus, Rajesh et al showed horizontal tear was the commonest meniscal injury (12%) followed by complex tear (11%), bucket handle tear (07%), radial tear (03%) and longitudinal tear (02%).[13] Also, the commonest type of tear involving lateral meniscus was horizontal tear (42.3%) followed by complex tear (26.9%), longitudinal tear (15.5%), vertical radial tear (11.5%) and oblique tear (3.8%).[13] Madurwar et al found that medial meniscus was involved in 34% cases against 22% cases of lateral meniscus.[10] Singh et al observed 32.9% patients had medial meniscus tear and 16.1% patients had lateral meniscus tear.[14]

Table 5: Various types and pattern of meniscal injuries.

Injuries		MM, (n=81) (%)	LM, (n=38) (%)
Grade-1 hyper-intensity	Anterior horn	Nil	1 (2.6)
	Body	Nil	Nil
	Posterior horn	2 (2.5)	3 (7.9)
Grade-2 hyper-intensity	Anterior horn	2 (2.5)	3 (7.9)
	Body	3 (3.7)	1 (2.6)
	Posterior horn	13 (16)	1 (2.6)
	Body and posterior horn	16 (19.7)	6 (15.9)
	Body and anterior horn	1 (1.2)	Nil
Longitudinal horizontal tear	Anterior horn	Nil	3 (7.9)
	Body	Nil	1 (2.6)
	Posterior horn	11 (13.6)	6 (15.9)
	Body and posterior horn	8 (9.9)	4 (10.5)
	Body and anterior horn	Nil	Nil
Longitudinal vertical tear	Anterior horn	Nil	Nil
	Body	Nil	Nil
	Posterior horn	2 (2.5)	Nil
	Body and posterior horn	Nil	Nil
	Body and anterior horn	Nil	Nil
Complex tear	Posterior horn	9 (11.1)	5 (13.2)
	Body	Nil	Nil
	Body and posterior horn	3 (3.7)	Nil
	Anterior horn	Nil	1 (2.6)
Radial tear	Posterior horn	4 (4.9)	1 (2.6)
Bucket handle tear		5 (6.2)	1 (2.6)
Posterior root tear		2 (2.5)	1 (2.6)

Table 6: Location of injury at meniscus.

Location	MM, (n=81) (%)	LM, (n=38) (%)
Ant horn	2 (2.5)	8 (21)
Body	3 (3.7)	2 (5.3)
Post	41 (50.6)	16 (42.1)
Ant horn + body	1 (1.2)	Nil
Post horn + body	27 (33.3)	10 (26.3)

Medial collateral ligament and lateral collateral ligament

This study showed 5.4% MCL tears and 2.4% LCL tear with various grades (Figure 2). Complete MCL tear was seen in 01 case. Grade-2 and grade-1 MCL sprains were seen in 03 and 07 cases respectively. 04 patients had complete LCL tear. Grade-1 LCL sprain was seen in 01 patient. Singh et al observed MCL tears in 7% cases and LCL tears in 3% cases.[14] However, in the study by Rajesh et al 17% cases of LCL tear and 9% cases of MCL tear were found.[13]

Other injuries

In this study, bony contusions were seen in 23.7% cases. These contusions were seen involving tibial and femoral condyles (Figure 3). Of these, 54.1% contusions were seen involving simultaneous involvement of lateral femoral and lateral tibial condyles. Various studies have shown the incidence of bony contusions in a range of 42% to 46%.[10,13] In this study, chondral lesions were seen in 5.1% cases. The combined injury involving ACL, MCL and medial meniscal injury, also known as O'Donoghue triad, was seen in 1% cases. This finding corroborates with study by Rajesh et al wherein this triad was seen in 1% cases.[13]

Complete ACL tear, complete PCL tear, complex posterior horn tear, bucket handle tear, radial tears, vertical tears of menisci are surgically significant tears.[1] In present study, 19.8% surgically significant tears were found.

Limitations and strengths

Main strength of this study was the targeted study group. Sports related injuries are usually related to acute trauma and MRI has high sensitivity to detect acute injuries. Also, all these patients had undergone clinical examination by orthopedician before the MRI due to which the clinical inputs had helped in the radiological evaluation for all cases on MRI. There were few limitations also. Being a retrospective study, the findings of surgically insignificant injuries were based on available literature and were not confirmed by arthroscopy. However, the MRI imaging is known to have high diagnostic accuracy for the post-traumatic knee injuries. It is noteworthy that there could have been some discrepancies while reporting surgically insignificant injuries if, theoretically speaking, arthroscopy was done in all cases. However, this was unlikely to influence the results of surgically significant injuries found in this study.

CONCLUSION

A significant number of surgically significant injuries can be found during sports associated trauma. MRI is the modality of choice in a post-traumatic knee. The AI software makers should focus primarily on the identification of ACL and meniscal injuries which can be helpful in conducting big scale research projects on post traumatic knees. AI can also be helpful to the radiologists in early phase of MRI training in knee injuries.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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