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Case Report

# Management of sports-related and recreational knee injuries in children: surgical aspects

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## Abstract

Sports-related knee injuries are common in children and the management of these injuries continues to evolve. Sports injuries in children affect both growing bone and soft tissues and can result in damage of growth mechanisms with subsequent lifelong, growth disturbance. With an increasing number of paediatric and adolescent athletes presenting with knee injuries due to sports, a greater demand is put on clinicians and radiologists to assess the specific type of knee injury.

Traumatic forces applied to the immature skeleton cause a different type of injury than those seen in adults due to the differences in vulnerability of the musculoskeletal system, especially at the site of the growth cartilage. An overview of several sport-related knee injuries of young athletes is presented, based on anatomical location and their management. The training programmes should be considered an important training tool that growing athletes can adjust to the changes in their bodies and could prevent knee injuries..

Keywords: sports-related Knee Injuries in children, Knee injuries in adolescent sports players

## INTRODUCTION

Physical activity is an important component of health and well-being for people of all ages [1,2]. It has been directly linked to increased physical competency, decreased health risks, decreased body mass index, and increased social interaction [3]. Physical activity also carries a risk of injury which can exact psychological, emotional, physical, social, and economic tolls [3-6]. Participation in physical activities such as sports and recreation has been identified as a strong risk factor for knee injury [4-10].

Knee is the most injured joint by adolescent athletes [7-9]. Prevention is important because a knee injury can end an athlete's competitive career and can permanently affect physical activity capabilities among individuals of all ages. Additionally, while knee injuries can have economic effects on the injured individuals, they also pose a burden on the health care system [11]. Knee injuries are reported to account for 60% of high school sports-related surgeries, and female athletes have been reported to be four to six times more likely to sustain a major knee injury [12].

Additionally, researchers have attributed the vulnerability of female knees to numerous factors, including anatomical, environmental, hormonal, neuromuscular, and biomechanical differences [13,14]. Increased use of indoor electronic games meant that young people spend less amount of time in sports-related physical activities. There has been an increased incidence of obesity in children [15].

The knee joint is one of the most common sites of injuries in the skeletally immature patient, with the spectrum of injuries differing from those in adults. Children are not 'little adults' and have different physiology, anatomy, presence of growth plate (weak area), different blood supply and weak surrounding muscle strength and mechanics [16].

Sports-related knee injury prevention efforts include a variety of approaches such as sport-specific skills training (e.g., planting and changing direction, jumping/landing); strengthening and conditioning programs aimed to address potential deficits in the neuromuscular strength and coordination of stabilizing muscles about the knee joint; and combined programs of stretching, plyometrics, and strength training drills [17,18].

**Table 1.** Data is collected from hospital records with epidemiological distribution among both sexes

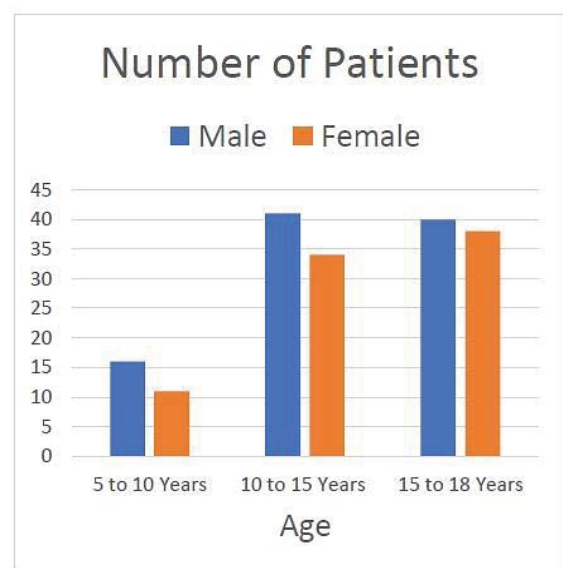
Age	Male	Female	Number of Patients
5 to 10 Years	16	11	27
10 to 15 Years	41	34	75
15 to 18 Years	40	38	78
Total	97	83	180

This article is focused to present a case series of knee injuries in children that happened during various sports and recreation and their management. These patients were managed in our institution with various modalities of treatment depending on the type of Knee injuries. In addition, we set out to study the associations between age, sex and types of knee injuries.

## MATERIALS AND METHODS

An electronic search of the PubMed, EMBASE, and Google Scholar databases for keywords related to knee sports-related injuries' and 'adolescent and athletes' was performed. Each manuscript was individually reviewed. For all cases of knee injuries in children secondary to sports, presentation, treatment, and outcome were recorded. Papers were selected based on expert opinion and consensus by the authors and included if deemed to have contributed important findings to the above topics.

It is a retrospective descriptive study. Clinical and radiological Hospital records of knee injuries in children, from 2000 to 2021, were randomly selected as a regional representative sample from 180 patients with sports-related and recreational knee injuries from our institution. Patient demographics as well as mechanism of injury and treatment offered were recorded. Data was segregated according to various variable like age, sex, type of injuries and treatment given. (Tables 1 and 2 and Graphs 1-3).



**Graph 1:** Bar graph of number of patients

**Table 2.** Type of injuries for all age groups

Types of Injuries	5 to 10 Years	10 to 15 Years	15 to 18 Years	Total
ACL avulsion injury	2	12	10	24
Patellar Dislocation	10	21	9	40
PCL Injuries	2	4	2	8
Meniscal Injuries	1	4	6	11
Knee Dislocation	1	2	4	7
Distal femur physeal injuries	2	4	1	7
Proximal Tibial Physeal Injuries	4	8	6	18
Osteochondral Femoral Condyle Injuries	3	5	2	10
Osteochondral patellar injuries	1	4	8	13
Patellofemoral ligamentous injuries	1	6	10	17
Discoid meniscus Injuries	2	4	1	7
Meniscal cyst	1	2	1	4
Quadriceps and patellar tendons ruptures	2	8	4	14

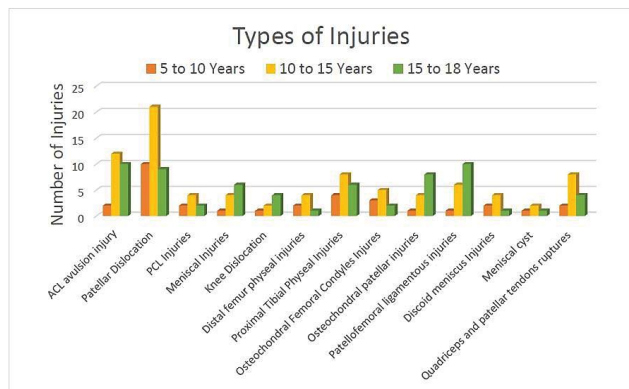
## Cases and their management

Following are the details of various sports-related knee injuries of young patients and treatment offered and algorithm.

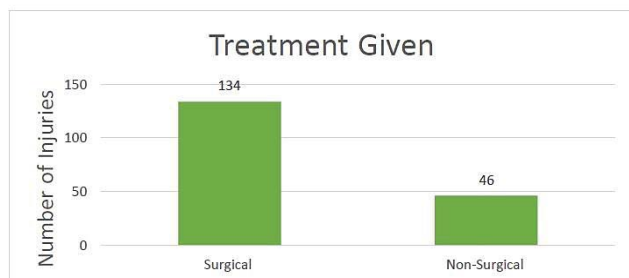
### Case 1: ACL Tibial spine avulsion injury

ACL Tibial spine avulsion injury is shown in Cases 1a, 1b, and 1c

Note: We managed Modified Meyers and McKeever non-displaced type I and reducible type II fractures by immobilization in full extension.



Graph 2: Bar graph of types of injuries in different age groups



Graph 3: Type of treatment given

Type III or Type II fractures that cannot be reduced were managed by Arthroscopic fixation using suture. These patients were safely and more appropriately treated with transphyseal reconstruction using small 7 mm-8 mm drill holes and Fibre wire sutures. Patients and parents were counselled that there remains a small risk of physical injury and a possibility of additional surgery for angular or growth disturbance.

### Case 2: ACL injury with open physis

ACL injury with open physis is shown in Case 2a, 2b, 2c and 2d

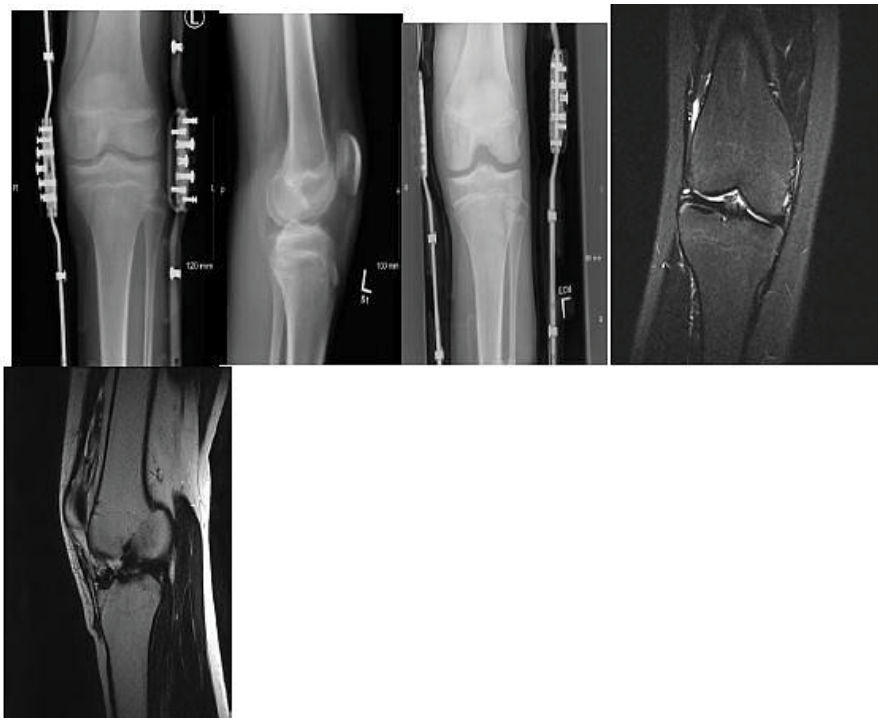
Note: The treatment of ACL tears in the paediatric population is challenging and controversial. Younger age Patients group (5-12) with open physis were offered the option of activity modification, functional bracing, rehabilitation, and careful follow-up. Surgery was indicated in skeletally immature patients with a torn ACL and an additional repairable meniscal injury and in patients who failed conservative care. Another option for the completely immature paediatric athlete was a more technically demanding all-epiphyseal procedure using hamstring tendon grafts.

In the mid-age child (skeletal age 12 to 14 in girls and 13 to 16 in boys), physeal-sparing methods may be selected; however, many of these intermediate-maturity patients were safely and more appropriately treated with transphyseal reconstruction using small 7 mm-8 mm centrally placed drill holes and a soft tissue graft, such as the hamstring tendons. Patients and parents were counselled that there remains a small risk of physeal injury and a possibility of additional surgery for angular or growth disturbance. Last, adolescents who are approaching skeletal maturity (skeletal age older than 14 in girls and older than 16 in boys,) were undergone anatomic ACL surgery with tibial and femoral drill holes and hamstring graft with minimal risk of physeal injury.

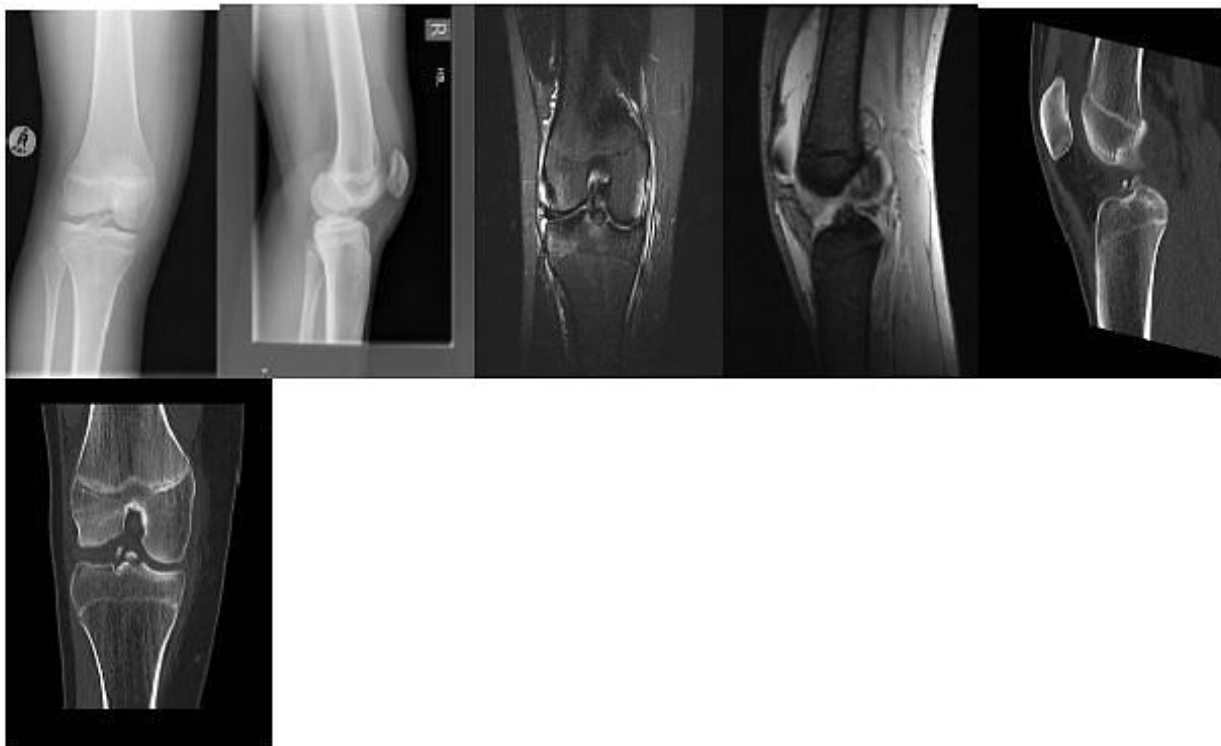
### Case 3: Patellar dislocation

Patellar dislocation is shown in case 3a and 3b

Note: All patients with patellar dislocation who had reduced at the place of injury or manually reduced in ED, were initially managed in dynamic knee brace and physiotherapy. Most of these patients were improved with conservative treatment. Further scanning was planned



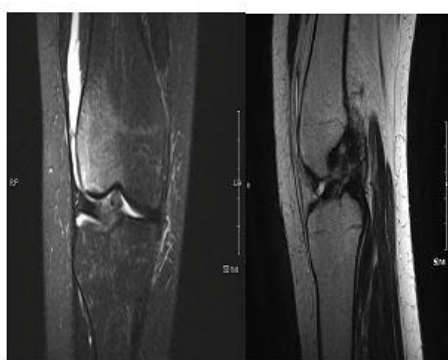
**Case 1a:** Undisplaced type I Meyers & McKeever managed conservatively with brace locked in extension for 6 weeks. union achieved without any growth arrest at maturity confirmed on MRI



**Case 1b:** Displaced Meyers & McKeever type II managed with arthroscopic suture fixation and after union loose bodies' removal



**Case 1c:** Displaced Meyers & McKeever type II managed with arthroscopic suture fixation and achieved union



**Case 2a(i):** Pre-operative MRI showed ACL tear with partially open upper Tibial Physis

who failed conservative management. MRI Knee were arranged to see rupture of medial patellofemoral ligament and osteochondral fracture. Arthroscopic removal of loose body or repair of osteochondral fracture was performed in symptomatic patients. Medial Patellofemoral ligament reconstruction were performed acutely in first time dislocation with large bony fragment and medial patellofemoral reconstruction using hamstring graft in patients having recurrent instability with ligament rupture after making sure that there is no underlying malalignment.

#### **Case 4: Meniscal injuries**

Meniscal injuries are shown in case 4a and 4b.

Note: Meniscal tears in paediatric patients are often associated with other pathology such as ACL tears, tibial eminence fractures or the presence of a discoid meniscus. We repaired all meniscus tears associated with





**Case 2a(ii):** Post op x rays after ACL Reconstruction and MRI after physis closed no growth arrest



**Case 2b:** Pre-operative MRI showed ACL tear with partially open upper Tibial Physis and Post op x rays after ACL Reconstruction



**Case 2c:** Pre-operative MRI showed ACL tear with partially open upper Tibial Physis and Post-op x rays after ACL Reconstruction



**Case 2d:** ACL and lateral meniscus Tears. ACL Reconstruction and Lateral Meniscus Repaired at the same time

ACL at the time of reconstruction and symptomatic standalone tears in red-red and red-white zones with in-side out technique/all inside using FAST-FIX 360, arthroscopically.

### **Case 5: Distal femur physeal injuries**

Distal femur physeal injuries are explained in cases 5a and 5b

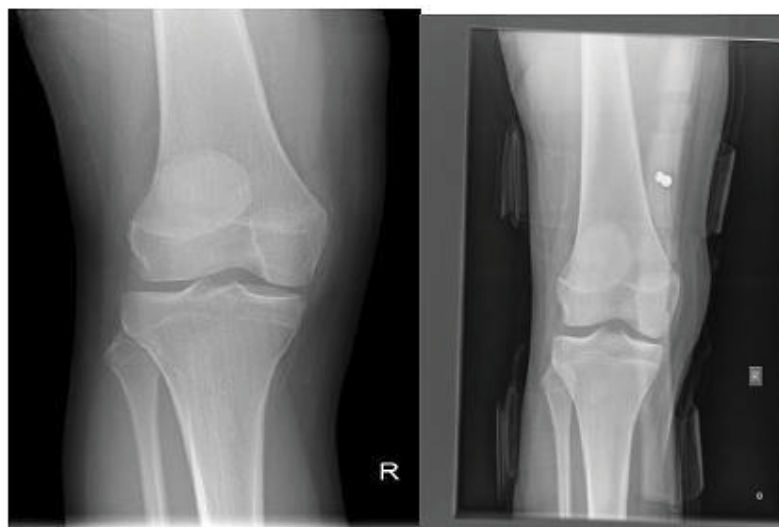
Note: We managed nondisplaced fractures with long leg casting for

4-6 weeks. Closed reduction and percutaneous fixation followed by casting were applied for displaced Salter-Harris I or II and some Salter-Harris III or IV injuries if anatomic reduction were achieved. Displaced fractures successfully reduced with closed methods were still secured with fixation as fracture pattern are unstable. ORIF with Plate and screws were used for Salter-Harris III and IV with weight-bearing articular involvement.

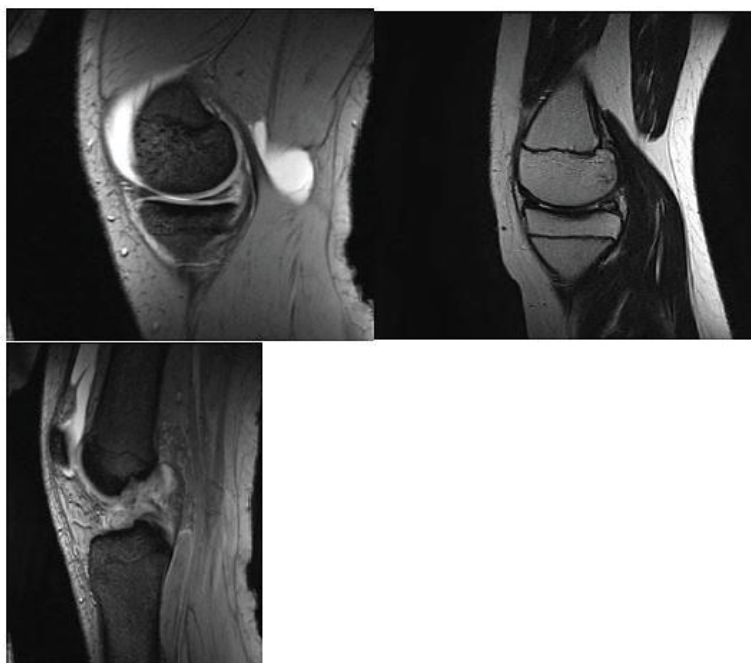
Irreducible type II fractures were most often due to interposed



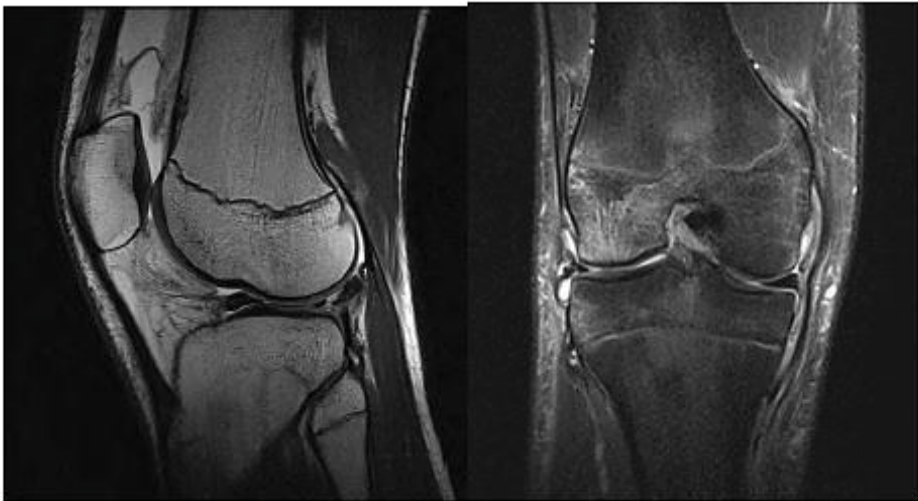
**Case 3a:** Post traumatic patellar dislocation, reduced under sedation in ED and managed conservatively with brace and physiotherapy



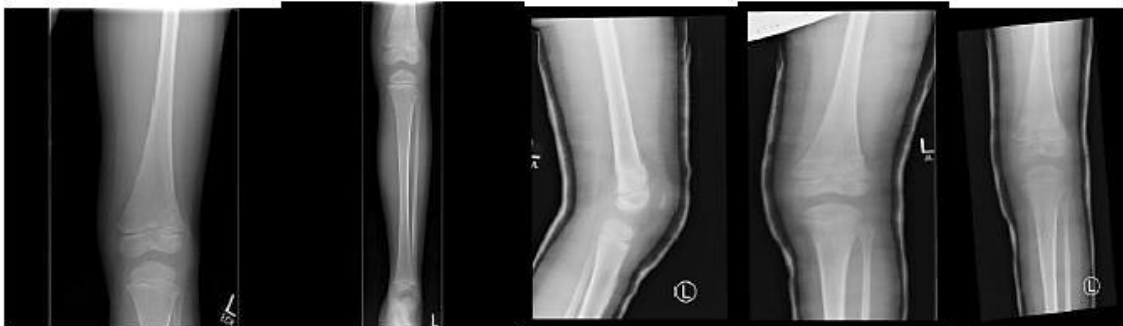
**Case 3b:** Patellar dislocation reduced at scene of trauma, managed with dynamic brace and physiotherapy



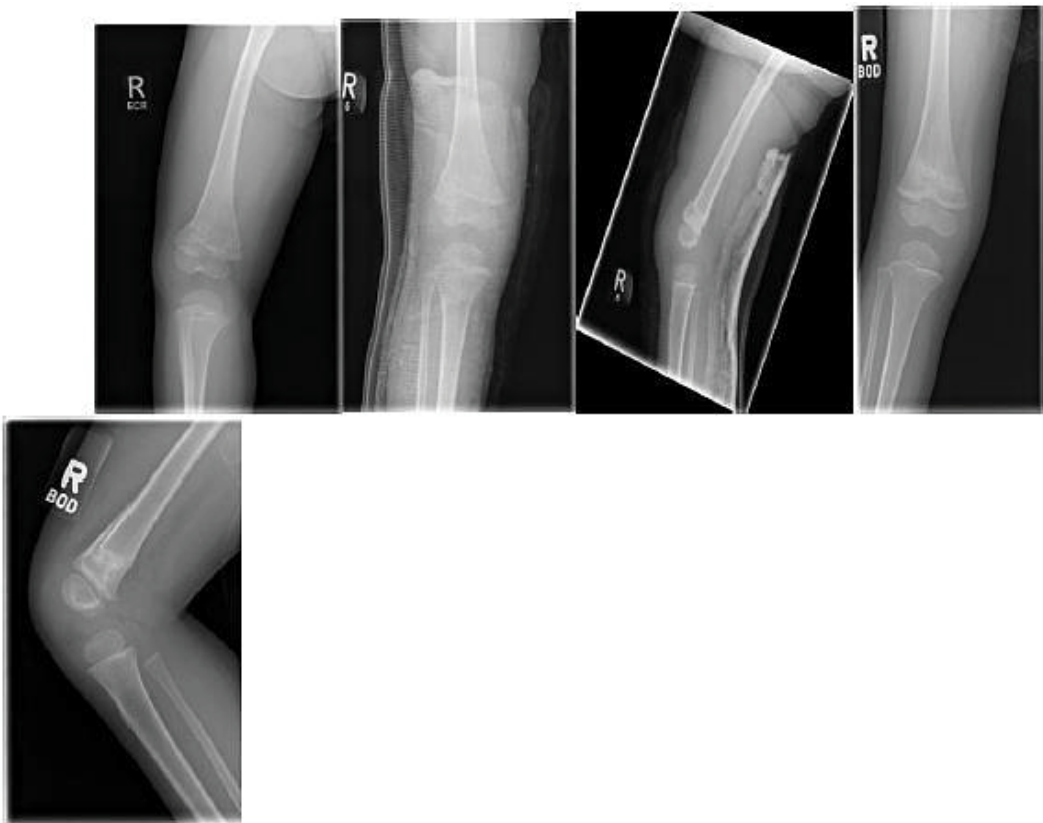
**Case 4a:** Medial meniscal with ACL tear



Case 4b: ACL with bucket handle lateral meniscus tear



Case 5a: Undisplaced Salter Harris II distal tibial physeal fracture, managed conservatively in above knee POP with healing



Case 5b: Undisplaced Salter Harris II distal tibial physeal fracture, managed conservatively in above knee POP with healing

periosteum on the tension side of fracture.

### Case 6: Proximal tibial physeal injuries

Proximal tibial physeal injuries are shown in cases 6a, 6b, 6c and 6d

Note. We had treated undisplaced fracture with long leg cast in extension for 6 weeks and open reduction internal fixation with arthrotomy +/- arthroscopy for Type II-IV fractures - according to Ogden (modification of Watson-Jones) classification.

### Case 7: Osteochondral femoral condyles injuries

Osteochondral femoral condyles injuries is explained in case 7a, 7b and 7c

Note: most of undisplaced and small size injuries in younger age group (Category 1 according to Pappa's classification) were managed conservatively with NWB/TOE touch bearing for 6 weeks and then full ROM and had healed very well due to high healing potential in this

age group. Lesions in older age group (category II & III) were managed according to size of lesion and displacement and detachment pattern with arthroscopic removal of detached fragment, retrograde drilling, headless screws fixation, Chondroplasty, Mosaic plasty, OATS and ACI. Cartilage repair and restoration appeared to be fair better when compared to microfracture alone.

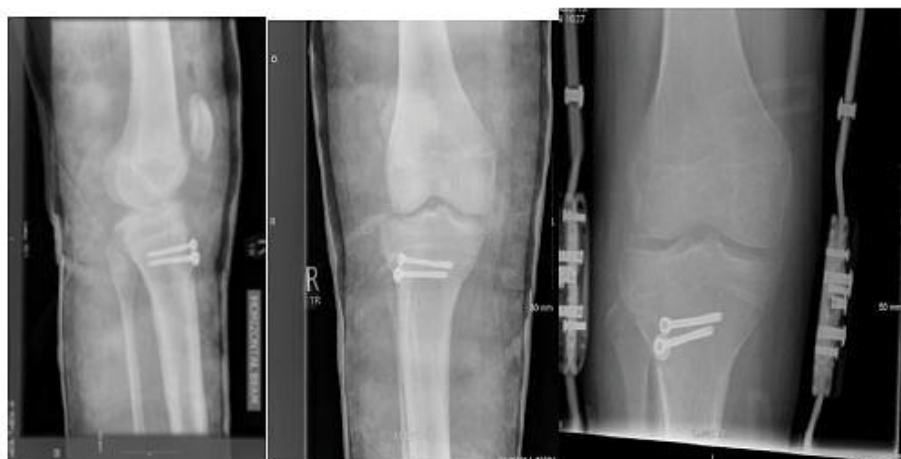
### Case 8: Osteochondral patellar injuries

Osteochondral patellar injuries are shown in case 8a, 8b and 8c

Note. Osteochondral patellar fractures were usually associated with patellar instability and patellar dislocation. Most of these patients were improved with conservative treatment. Further scanning was planned who failed conservative management. MRI Knee were arranged to see rupture of medial patellofemoral ligament and osteochondral fracture. Arthroscopic removal of loose body or repair of osteochondral fracture were performed in symptomatic patients. Medial Patellofemoral ligament reconstruction were performed acutely in first time

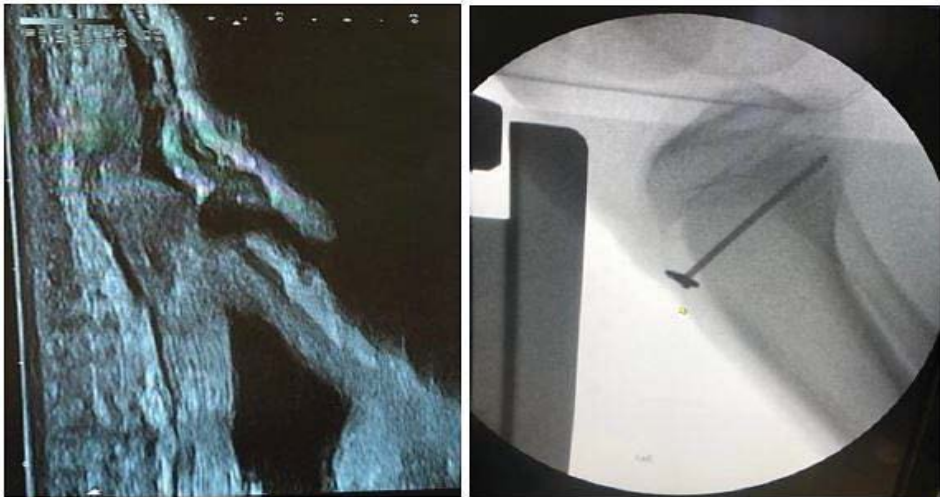


**Case 6a(i):** Proximal tibial physeal injury treated with P/C Screw Fixation sparing physeal plate



**Case 6a(ii):** Post Healing xrays

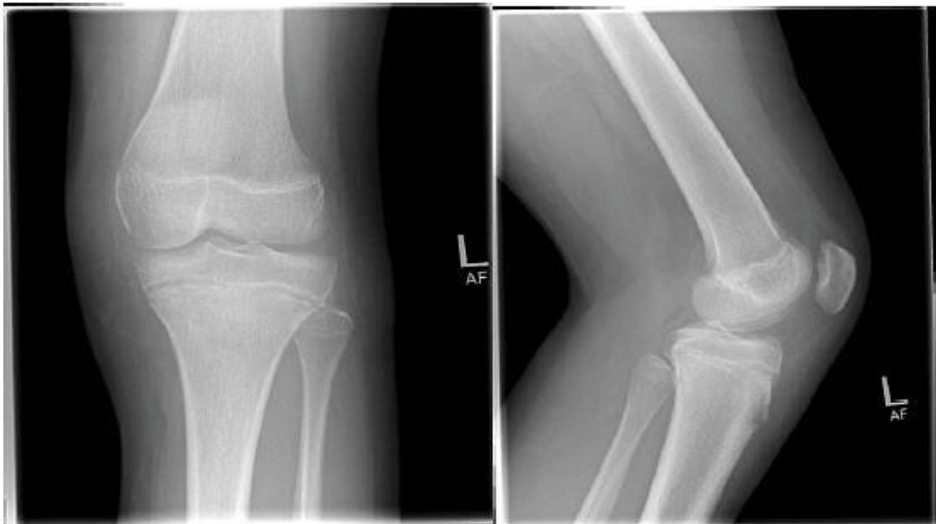




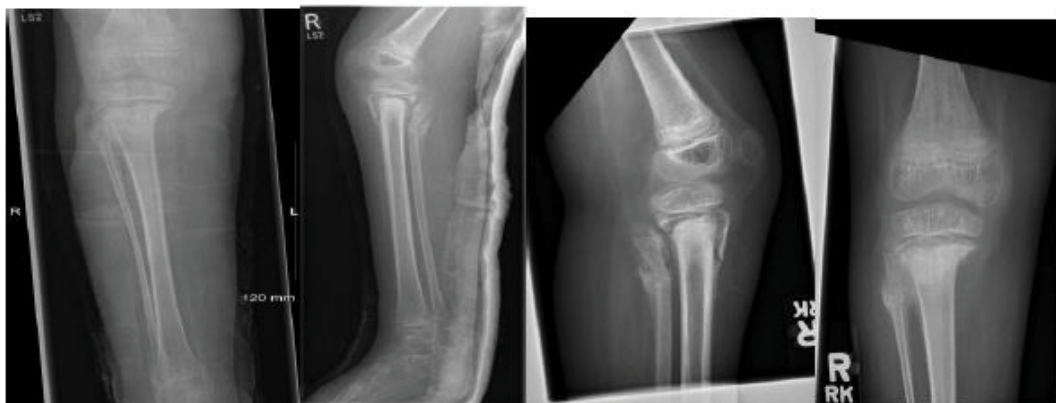
**Case 6b:** Patellar tendon avulsion of tibial tubercle cartilaginous sleeve tibial tubercle(ultrasound)



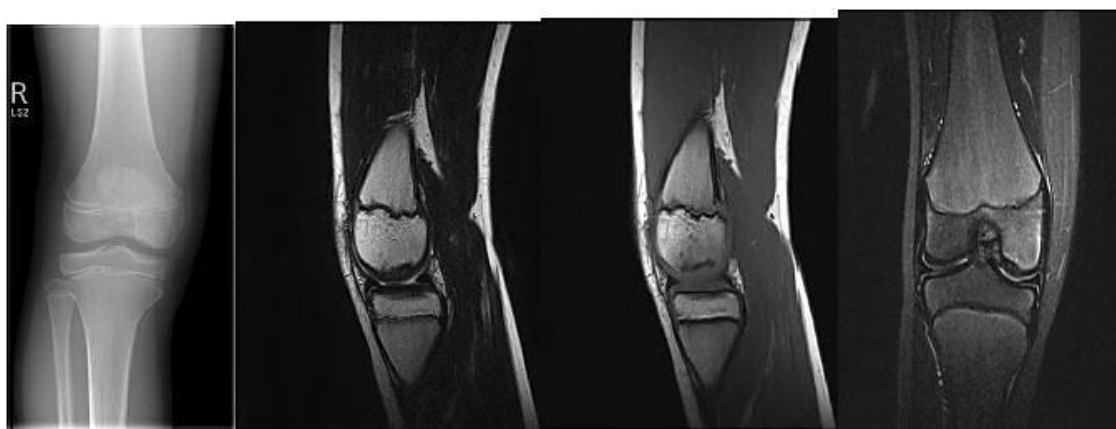
**Case 6c(i):** Undisplaced proximal tibial physis fracture evident on MRI , managed conservatively



**Case 6c(ii):** Post healing x rays



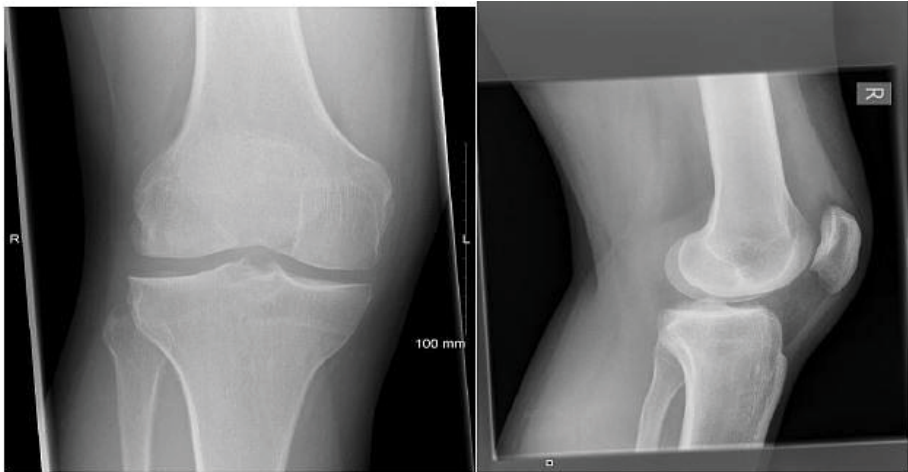
**Case 6d:** Infant child with severe injury, managed conservatively



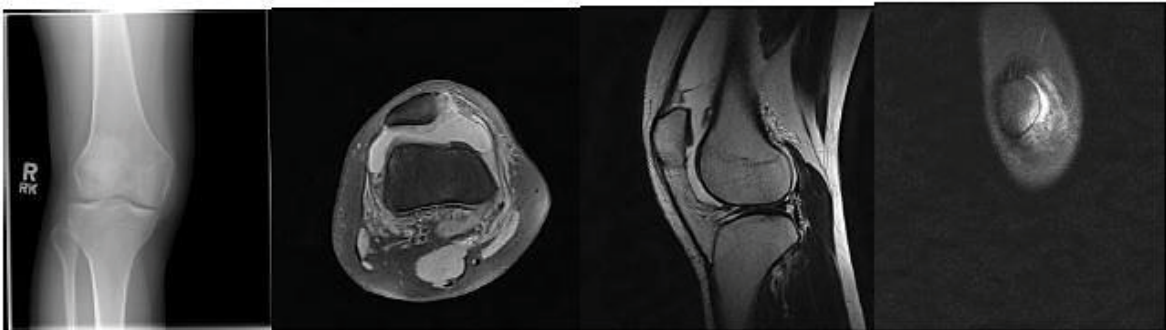
**Case 7a:** Stable osteochondral medial femoral condyle fracture



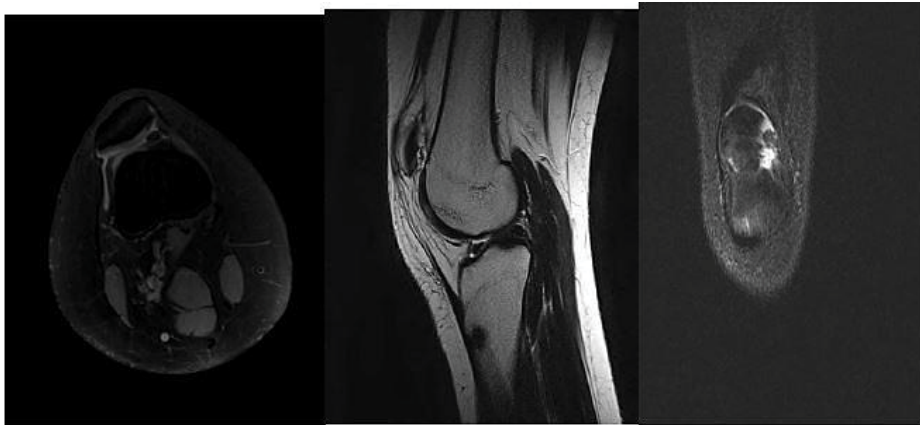
**Case 7b:** Stable osteochondral lateral femoral condyle fracture



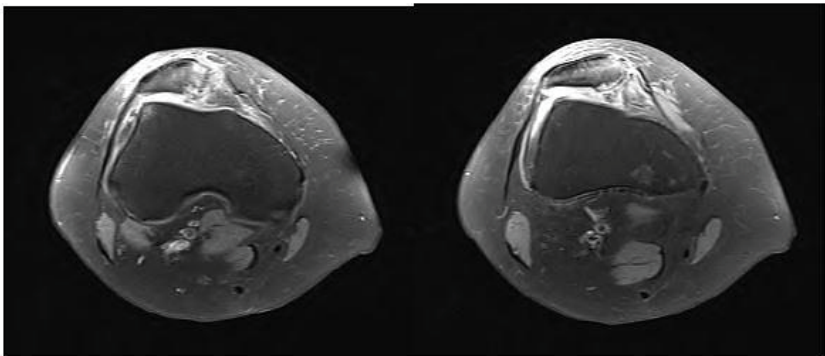
**Case 7c:** OATS procedure done for osteochondral fracture of medial femoral condyle 10 years back



**Case 8a:** Osteochondral fracture medial facet of patella



**Case 8b:** Osteochondral fracture medial facet of patella



**Case 8c:** Osteochondral fracture medial facet of patella with medial retinacular and MPF Ligament tear

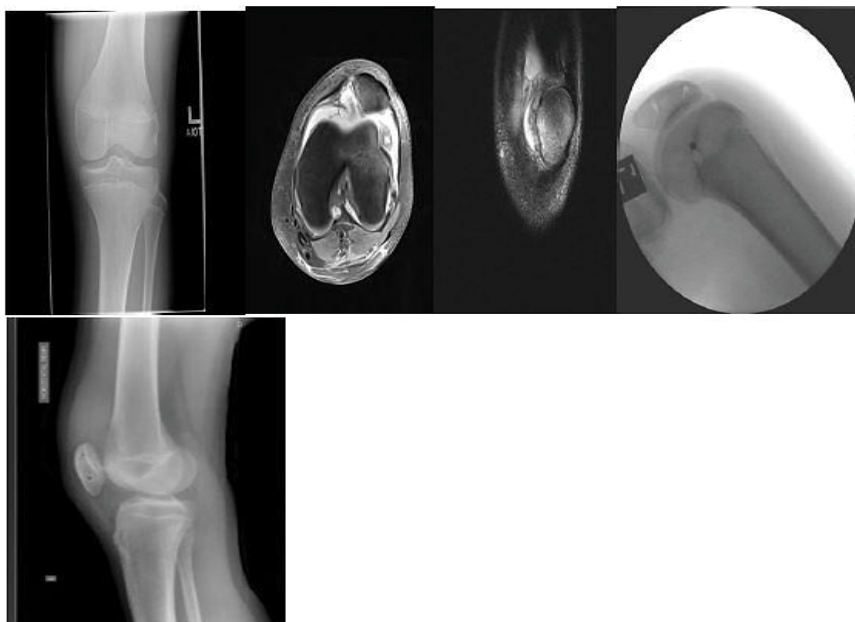


dislocation with large bony fragment and medial patellofemoral reconstruction using hamstring graft in patints having recurrent instability with ligament rupture after making sure that there is no underlying malalignment.

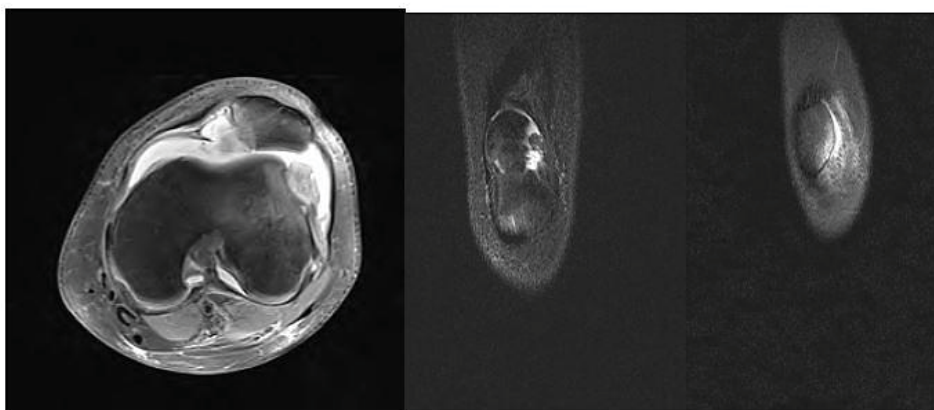
### Case 9: Patellofemoral ligamentous injuries

Patellofemoral ligamentous injuries are shown in case 9a, 9b and 9c

Note: Most of these patients were improved with conservative treatment. Further scanning was planned who failed conservative management. MRI Knee were arranged to see rupture of medial patellofemoral ligament and osteochondral fracture. Arthroscopic removal of loose body or repair of osteochondral fracture were performed in symptomatic patients. Medial Patellofemoral liagment reconstruction were performed actutely in first time dislocation with



Case 9a: MPFL Reconstruction



Case 9b: MPFL Tear on MRI



Case 10a: Discoid lateral meniscus on MRI



large bony fragment and medial patellofemoral reconstruction using hamstring graft in patients having recurrent instability with ligament rupture after making sure that there is no underlying malalignment

### Case 10: Discoid meniscus Injuries

Discoid meniscus Injuries are shown in case 10a, 10b and 10c.

Note: Most of the discoid Meniscus were managed conservatively who were asymptomatic or having mild symptoms. Arthroscopic saucerization of discoid meniscus or repair of discoid meniscal tear with all inside technique using Fast-Fix 360 suture, respectively.

### Case 11: Quadriceps and patellar tendons ruptures/Patellar fracture and Patellar sleeve avulsion injuries

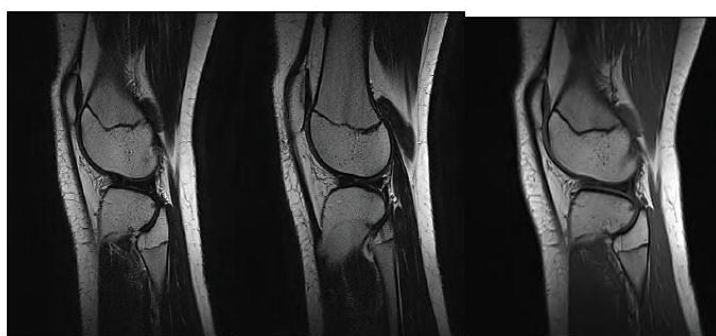
Quadriceps and patellar tendons ruptures/Patellar fracture and Patellar sleeve avulsion injuries are shown in case 11a, 11b, 11c and 11d

Note. These patients were managed with cylinder cast for 6 weeks for nondisplaced fractures with intact extensor mechanism and open reduction and internal fixation with TBW for fractures with 2 mm-3 mm displacement or 2 mm-3 mm articular step-off or disrupted extensor mechanism. We used bony anchors and fibre wire for patellar or quadriceps tendons rupture cases.

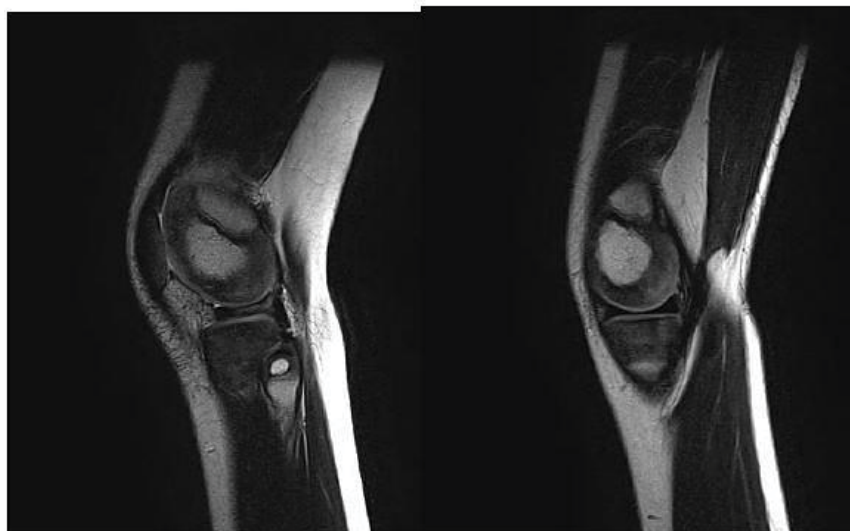
### Case 12: Collateral ligaments injuries

Collateral ligaments injuries are shown in cases 12a and 12b.

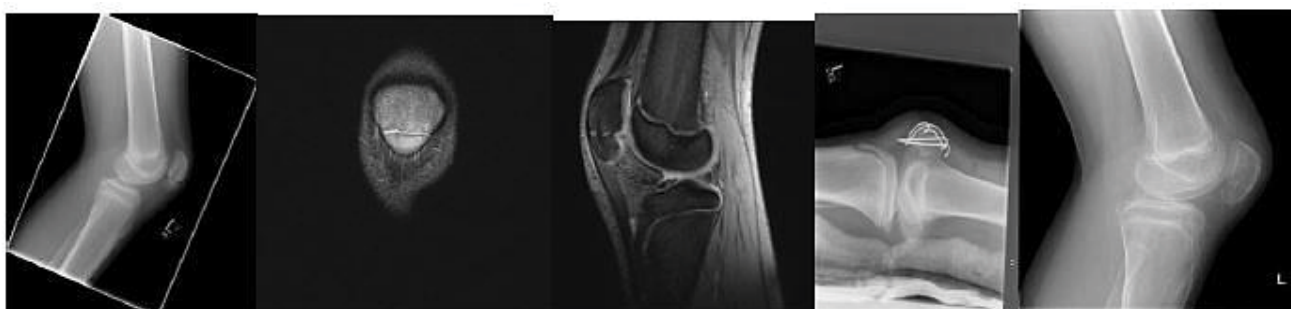
Note. Isolated collateral ligament injuries are rare in adolescent athletes. MCL injuries, one-quarter of which occurred in conjunction with patellar instability events, were 4 times more common than LCL injuries, one quarter of which have other posterolateral corner structures involved. Grade III injuries represent 20% to 25% of collateral ligament injuries and occurred most in football and soccer.



Case 10b: Discoid lateral meniscus on MRI



Case 10c: Discoid lateral meniscus on MRI



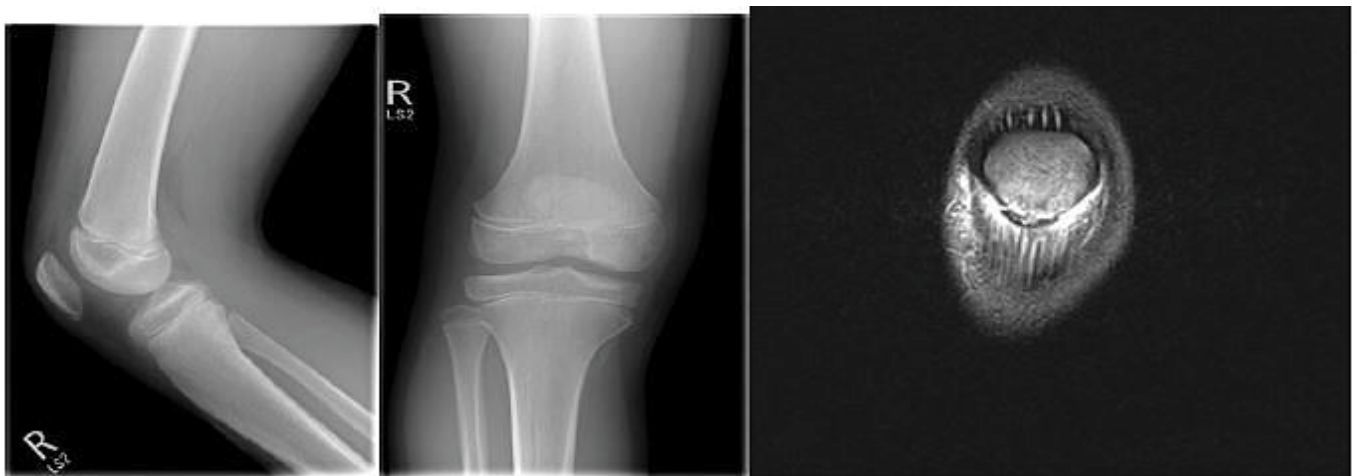
Case 11a: Lower pole patella fracture managed with TBW



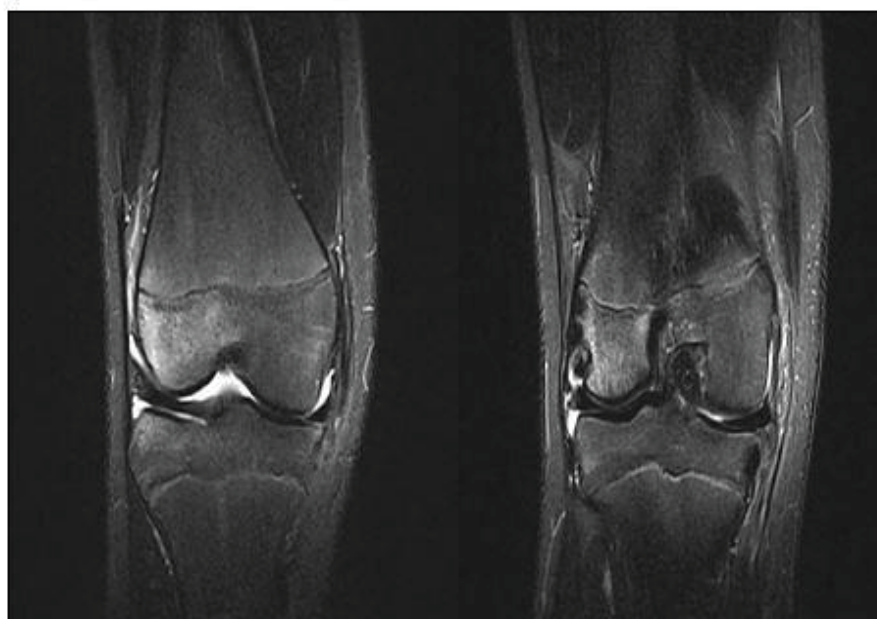
**Case 11b:** Undisplaced lower pole patella fracture managed conservatively



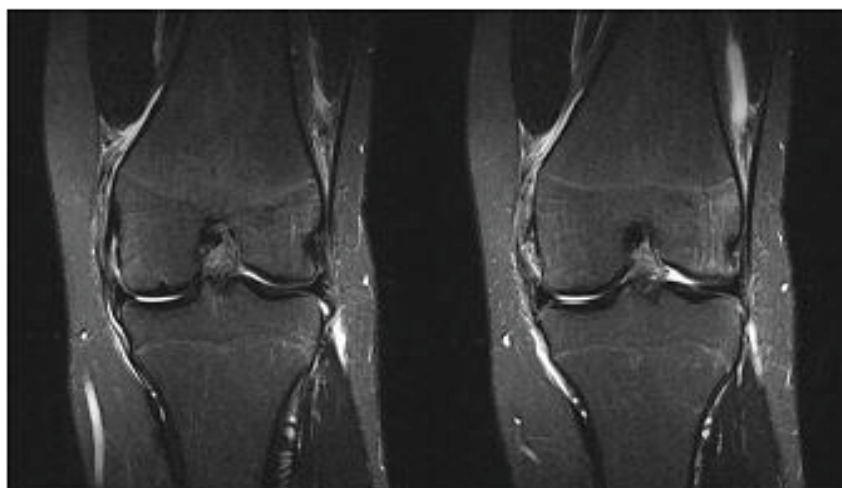
**Case 11c:** Lower pole patella fracture managed with TBW



**Case 11d:** Patellar tendon sleeve fracture



**Case 12a:** Medial Collateral ligament injury



**Case 12b:** Medial Collateral ligament injury

## DISCUSSION

With the high levels of physical inactivity around the world, increasing physical activity has become a key element of public health promotion [19]. Physical activity provides a great deal of benefits to health and well-being [20,21]. So great in fact that it is promoted as a medicine or a drug against life-style related diseases [22]. Nonetheless, Physical Activity as health promotion tool is not one without adverse effects. Participation in PA is the main cause of adolescent unintentional injuries in many developed countries [23]. Participating in organized sports in adolescence is a major risk factor for hospitalization throughout adolescence and on to early adulthood [24]. However, most injuries can be prevented.

Several studies have already been published describing sports related knee injuries in children. There are few epidemiological studies are present in literature on knee related sports injuries but none of these had addressed the evidence-based management plan. Some focus on professional athletes, others focus on college students or high school students and others on adult athletes [11,25]. Some studies focus only on a specific region of the knee or a specific diagnosis, such as

ACL injuries, about more incidence of ACL injuries in female [12], osteochondral (OCD) or Patellar instability [26], and many compare injuries rates between sexes [26,27]. High-level, descriptive outcomes research on a variety of paediatric sports related knee injuries is lacking and this review may help inform topics for future study.

There are only two comprehensive studies as case series of sports-related knee injuries in children on PubMed search [25,27]. But both studies detail about epidemiology of these injuries with very limited knowledge of accurate diagnosis and management. This is the first case series study of paediatric knee injuries presented with pictures of sample cases treated and provided some unique information about such fractures' characteristics and their management.

Brett E. Gage and colleagues [27] had presented an epidemiology of paediatric knee injuries seen in ED and had provided the data about distribution of knee injuries in various seasons, gender, and type of knee injuries. This study has not provided any information about type of management given.

A recent study by Richmond et al. [28] demonstrated that a school-based neuromuscular training intervention reduces the risk of PA-

related injuries while simultaneously improving health markers. Furthermore, several studies have shown that it is possible to prevent adolescent injuries in organized sports by neuromuscular training [17,18,29].

One established risk factor for sports-related injury is a previous sports-related injury [30-32]. Therefore, one of the most efficient ways to reduce injury rates is to prevent the first injuries. Injuries can have short- and long-term consequences on adolescent health. In short term, an injury can lead to unfavourable weight gain and negative changes on obesity markers [15,33]. In long term, the risk of osteoarthritis later in life is increased [34,35]. The fear of further injury can limit participation and lead to dropping out of PA. Because of reduced activity, individuals will eventually lose the health benefits produced by PA and this will have negative effects on public health. To achieve best possible results, all PA promotion efforts should include injury prevention into their agenda [36].

Injury prevention programs target movement patterns by incorporating strength, plyometrics and sports-specific agility training [35-37]. Coach and athlete education on cutting/landing techniques (e.g.,

wide foot position when cutting, flexed knee when landing) that avoid high-risk knee positions are also fundamental. Injury prevention programs are straightforward to implement because they require little to no equipment and are performed as part of regular team training or physical education 2-3 times per week [38,39].

## CONCLUSION

Knee injuries present one of the highest clinical and public health injuries-related burdens, given the high incidence of knee injuries across the age continuum and the frequent need for surgical repair and long-term rehabilitation. Although a certain endemic level of knee injury in children will always be associated with physical activity, and efforts to increase physical activity levels among the children must continue to be supported, an increased commitment should be made to reduce the number and severity of knee injuries in the children.

High-quality injury prevention programs are the first-line defence against the potential negative short- and long-term consequences of knee injuries. However, if injury prevention efforts fail, timely and accurate diagnosis is important since diagnosis is the starting point for effective management planning and shared decision-making.

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