3. Biomechanics

The tensile strength of native ACL has been estimated to be within the range of 1725 ± 269 N [12]. ACL was initially thought be subjected to isometric stresses throughout the range of motion; however, biomechanical studies demonstrated that the ACL is subjected to differential stresses in movement of the knee [13]. The anteromedial bundle experiences maximum stress in flexion, while posterolateral bundle experiences maximum stress in extension [14]. The posterolateral bundle bears the majority of the stress during knee motion. The single-bundle ACL reconstruction had stressed upon the restoration of anteromedial bundle leaving behind the posterolateral reconstruction [15]. Consequently, it was noticed that there were experiences of rotational instability and persistent pain in almost 31% cases. There has been now shift in focus from single-bundle to double-bundle ACL reconstruction improving the knee biomechanics.

4. Mechanism of injury

In majority of the cases, the flexed knee is subjected to rotational stress leading to ACL injury. The contraction of quadriceps leads to subluxation of the tibia anteriorly with failure of hamstrings to prevent the anterior subluxation.

In contact sports like football and hockey, the direct blow from the lateral aspect of the knee in a flexed and externally rotated position leads to tear in medial collateral ligament (MCL) and anterior cruciate ligament.

5. Diagnosis

5.1. History

The athlete gives a history of twisting injury to knee with popping sensation. There is associated swelling and pain. There is sensation giving away of the knee with respect to body. There are marked variations in the presenting symptoms ranging from mild pain and swelling to inability to bear weight. In the presence of associated injuries like fracture of the tibial shaft or femur, the injury to ACL is sometimes missed [16].

5.2. Physical examination

5.2.1. Swelling

There is swelling of the knee associated with the ACL injury due to hemarthrosis. The swelling might take some time before manifesting itself. The knee can be aspirated in selected cases of severe knee pain. If there are fat globules in the aspirate, then the intra-articular fracture is suspected.

over the patella, and the other is placed over the tibial tubercle. The arthrometer is secured to the leg with Velcro straps. The anteroposterior translation is measured by relative motion between sensory pads. When the examiner applies anterior force through handle, a tone is heard at 67, 89 and 133 N. The readings are recorded and evaluated. A side-to-side difference of less than 3 mm at 67 N and maximum force is considered normal. The side-to-side difference is more than 5 mm and is considered diagnostic of an ACL tear.

5.2.8. Range of motion

The movement of the knee is compared with the uninjured knee. The loss of extension is seen in cases with associated bucket handle tear of meniscus or torn fragments of ligament impinging anteriorly.

5.2.9. Assessment of collateral ligaments

The injured knee is given varus and valgus stress at 0 and 30° of flexion. The opening of medial or lateral joint space is graded from zero to three depending upon the amount of opening noticed on stress. Grade I injury is mild opening of less than 5 mm, grade II is opening between 5 and 10 mm, and grade III is opening of more than 15 mm.

5.2.10. Associated ligament injuries

It is important to document associated PCL and posterolateral corner injuries as the influence of the management of ACL injury.

5.2.11. Neurovascular assessment

It is imperative to document injures to neurovascular injuries though they are rarely associated with isolated ligament injuries.

5.3. Imaging

5.3.1. Radiographs

Anteroposterior and lateral radiographs of the knee are carried out to detect the bony avulsions, osteochondral fractures, and tibial plateau fractures.

5.3.2. Computerized tomography

It is used to detect the suspected tibial plateau fracture that may be associated with ACL injury.

5.3.3. Magnetic resonance imaging

In acute setting the hemarthrosis may mask the ACL and meniscal injuries and sometimes even the minor injuries to ACL present as significant strains. It may detect the associated bone bruises and other ligament injuries. Generally the MRI examination should be delayed by

2–3 weeks for correct assessment of ACL injury. However, it is important to note that a good clinical examination is more informative and useful that an MRI to assess knee ligamentous injury (**Figure 2**).

5.3.4. Examination under anesthesia

The patient should be examined under anesthesia to reconfirm the findings of previous examinations. Sometimes due to spasm of muscles and pain, the laxity of the knee may be graded on a lower scale; hence, examination under anesthesia is important to assess the ligamentous injuries.

5.3.5. Diagnostic arthroscopy

Sometimes the findings of the MRI and clinical examination are equivocal, and diagnostic arthroscopy is carried out to look for pathology. In few cases the MRI findings may be falsely positive which can be ascertained on diagnostic arthroscopy [18].

5.4. Treatment decision

The treatment of ACL should be individualized to the patient. The two options in ACL tear are:

a. Activity modification: the patient can opt for sports like cycling or swimming from contact sports. If there are no giving away episodes, then he can opt for conservative treatment.

b. ACL reconstruction: in order to prevent early degenerative arthritis and return to previous activity level, the patient is advised to undergo ACL reconstruction.

Various factors should be considered before opting for operative or nonoperative treatment.

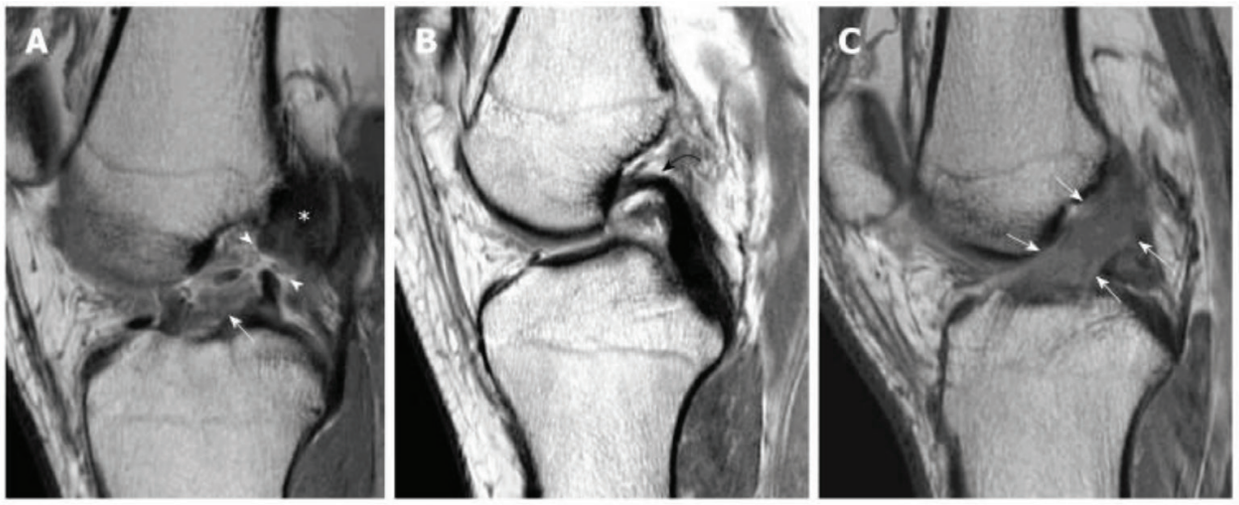

Figure 2. Signs of anterior cruciate ligament tear: (A) midsubstance discontinuity (white arrow heads), residual stump of ACL on tibial (white arrow), and femoral side (white asterisk); (B) complete resorption of ACL fibers and buckling of posterior cruciate ligament (PCL); (C) some fibers are shown in continuity (white arrows) suggestive of partial ACL tear (reprinted with permissions from Ref. [17]).

5.4.1. Age of patient

The older patients are given the option of nonoperative treatment with lifestyle modification. Young patients involved in sports activities are subjected to ACL reconstruction.

5.4.2. Activity level

The sportsperson shall require operative treatment in order to return back to sports activity of the same level.

5.4.3. Degree of instability

If side-to-side difference on KT-1000 arthrometer is more than 7 mm, then chances of successful surgical reconstruction are good.

5.5. Nonoperative management

a. The use of extension splints and crutches for mobilization in early ACL injury as it allows the healing of associated meniscocapsulolabral tears

b. Cryotherapy to reduce the swelling and pain

c. Range-of-motion exercises to regain the movement of the knee

d. Progressive strengthening exercises to regain tone of the quadriceps and hamstrings

5.6. Operative management

5.6.1. Timing of operative intervention

There is controversy over the timing of repair. Shelbourne had advised wait period of 3 weeks before reconstruction. He advocated that there are high chances of knee stiffness and loss of range of motion if operative procedure is carried out in acute phase [19]. However, Pinczweski reported good results with early reconstruction of ACL [20]. The general consensus is to wait till the swelling subsides, and good range of motion is achieved at the knee.

5.6.2. Graft selection

The various grafts available for ACL reconstruction are patellar tendon bone graft, hamstring graft, allograft, and synthetic tapes. The choice of graft depends upon the individual case, surgeon's experience, and preference.

In the 1970s, Erikson popularized the patellar tendon bone (PTB) as the graft for ACL reconstruction. It was the popular choice till the late 1990s. However, due to morbidity associated with the PTB, the focus was shifted to other grafts like hamstring graft, synthetic graft, allografts, etc. Fowler and Rosenberg popularized the use of hamstring graft. Initially there were apprehension about the strength of hamstring graft in comparison to PTB, but biomechanical testing and the use of newer fixation techniques like endobutton installed confidence

in minds of surgeons opting for it. The success of the reconstruction depends upon various factors like patient selection, surgical technique including correct tunnel placement, rehabilitation, and other associated ligamentous injuries.

5.6.2.1. Patellar tendon

It is considered as the gold strand in terms of graft for ACL reconstruction. There are advantages and disadvantages associated with this use of this graft.

5.6.2.1.1. Advantages

a. Early bone-to-bone healing at 6 weeks

b. Consistent size and shape of graft

c. Ease of harvest

5.6.2.1.2. Disadvantages

a. Harvest site morbidity: the common long-term problem is kneeling pain experienced with it. It was due to graft site morbidity that many surgeons had switched to hamstring tendons.

b. Anterior knee pain: injury to infrapatellar branch of the saphenous nerve can produce anterior knee pain. It may also be due to patellofemoral syndrome.

c. Late patellar tendon rupture.

d. Loss of range of motion.

e. Patella fracture: the cases of intraoperative patella fracture have been reported in patients when the graft was harvested with osteotome instead of saw. Sometimes the fractures are detected in late postoperative period due to overrun of saw. The stress risers that go beyond the limit of bone block should be avoided. The proximal saw cuts should preferably be boat shaped to avoid the stress riser formation.

f. Late chondromalacia of patella.

g. Patellar tendonitis: it leads to pain in some cases; however, it subsides by the end of the first year.

h. Quadriceps weakness: inadequate participation in the rehabilitation program can result in quadriceps weakness.

5.6.2.1.3. Indications for the use of PTB graft for ACL reconstruction

The ideal patient for this graft is young athlete who would like to continue in contact sports for a longer time. The elder individuals can also be advised to undergo ACL reconstruction but with a caution that they had to undergo aggressive physiotherapy following reconstruction procedure.

Conflict of interest

There is no conflict of interest in preparation of this chapter.

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