An Overview about Arthroscopic Fixation of Avulsed Tibial Spine

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Abstract

Background: Many questions arise when dealing with tibial spine injuries. Is anatomic fracture reduction necessary to avoid the need for later ACL reconstruction? What is the optimal fixation device? Can these fractures be treated through an arthroscopic approach effectively? Does age influence decision making and clinical results? Will early postoperative range of motion (ROM) decrease the risk of arthrofibrosis, which has been noted in previous studies on tibial spine fractures? The main goal of surgical treatment is to heal the displaced part in its anatomical position. Thus, it is aimed to prevent the possible knee joint instability and extension limitation. Screw fixation is an effective and safe surgical option with few complications. Screws can be inserted either retrograde or anterograde. Anterograde insertion is achieved with an aiming guide placed superoanterior to the inferoposterior direction with the knee at 900 of flexion. Retrograde screws are inserted from the anterior cortex of the proximal tibial through the tibial eminence fracture. The screw technique is simple, reproducible, and good fracture repair with almost immediate weight bearing postoperatively, on the other hand there are a few limitations to screw fixation. Cannulated screws may cause anterior impingement, fretting between the washer and screw, and damage of the articular surface, leading to a higher rate of implant removal. Another limitation is the ineffective fixation of small or comminuted fragments where insertion can lead to further comminution or displacement. In skeletally immature patients, growth disturbance and leg length discrepancy may occur as a result of screw damage to the physes.

Keywords: Arthroscopic Fixation of Avulsed Tibial Spine

Introduction

Many questions arise when dealing with tibial spine injuries. Is anatomic fracture reduction necessary to avoid the need for later ACL reconstruction? What is the optimal fixation device? Can these fractures be treated through an arthroscopic approach effectively? Does age influence decision making and clinical results? Will early postoperative range of motion (ROM) decrease the risk of arthrofibrosis, which has been noted in previous studies on tibial spine fractures? **(1)**

Tibial eminence fractures are significantly different regarding fracture type, associated intraarticular injury, entrapment of soft tissue within the fracture site, and extension of fracture into the tibial plateau. Treatment is based on these characteristics and designed to each fracture pattern. **(2)**

Displaced tibial eminence fractures disrupt the continuity of the femur-ACL-tibial viscoelastic chain and can cause mechanical block to knee extension. The goals of treatment, therefore, are to restore continuity of the ACL and its stabilizing function, eliminate the mechanical block caused by the fragments, and restore congruity of the tibial plateau. **(2)**

Although it is generally accepted that type II fractures can be treated conservatively also as type I. Surgical treatment of displaced fractures (type III and type IV) is essential to prevent nonunion or malunion, which can cause knee pain, disability, instability, or loss of extension. **(2)**

Immediate anatomic reduction and fixation of the fragments are widely recommended for type III and type IV displaced fractures. **(3)**

Type of fracture	Treatment
- Type I	Cast immobilization
- Type II	A) Closed reduction/cast immobilization. B) surgical treatment (arthroscopy vs. open)
- Type III	Surgical treatment (arthroscopy vs. open)
- Type IV	Surgical treatment (arthroscopy vs. open)

(Table.1) Types and therapy of fractures of the anterior tibial spine. **(3)**

A) Conservative treatment:

- **<u>Indication</u>:**

It is treatment of choice for type I, most of type II, and some of type III.

The treatment of type II fractures is more controversial than that of type I fractures; both operative and nonoperative treatments have been recommended. Nonoperative treatment is used for nondisplaced reduced fractures. **(4)**

Conservative treatment can be used in type III tibial spine fractures, but this technique is less successful in maintaining fracture reduction because the fragment is completely displaced. The lower likelihood of success may be due to the higher incidence of soft tissue entrapment in this fracture pattern. **(5)**

- **<u>Reduction:</u>**

Closed reduction is used in displaced type II fracture. It can be achieved by knee extension or hyperextension. Meyers and McKeever warned that closed reduction may convert a type II fracture to a type III fracture. Adequate reduction is confirmed by plain radiographs with weekly follow-up imaging to monitor redisplacement. If inadequate reduction or redisplacement occurs, arthroscopic or open reduction and fixation is recommended. **(2)**

- **<u>Immobilization:</u>**

Nondisplaced fractures can be treated nonoperatively by immobilization with long leg cast or fixed knee brace for 6 weeks. Aspiration of the knee hemarthrosis may be performed before casting to decrease swelling and pain. **(6)**

The position of immobilization remains controversial, as full extension or hyperextension is thought to reduce the fragment through direct compression by the lateral femoral condyle whereas at 200 of extension, there is a functional lengthening of the ACL. **(5)**

However, placing the knee in hyperextension may cause discomfort for the patient and can theoretically increase the risk of compartment syndrome because of excessive tension on the popliteal artery. **(5)**

B) Operative treatment:

The main goal of surgical treatment is to heal the displaced part in its anatomical position. Thus, it is aimed to prevent the possible knee joint instability and extension limitation. **(7)**

Although several fixation techniques have been reported, such as percutaneous K-wire fixation, metal screw fixation, staple fixation, and fixation with sutures passed through the tibial tunnel, insertion of cannulated screws, insertion of a wire loop, and insertion of sutures through or over the avulsed fragment are different methods to secure the fracture, no single treatment can be applied to all types of fracture. **(3)**

While deciding on the treatment technique of these fractures, the consideration of many factors, such as age, gender, body mass index (BMI), injury mechanism, and the experience of the surgeon, are important. **(7)**

- **Open or arthroscopy:**

Eilert first attempted arthroscopic reduction on tibial spine fracture with attached ACL in 1978. Since then, it has become a common practice to treat tibial spine fracture arthroscopically. **(1)**

In recent literature, ARIF, rather than open surgery, has become the standard of care. A mini-arthrotomy for ORIF may still be necessary in fractures that are irreducible by arthroscopic means. **(2)**

Arthroscopic management is considered ideal because it uses a smaller incision and results in less soft tissue damage, better pain control, early rehabilitation, direct visualization of intra-articular injuries, accurate reduction of fracture fragment, and allows for simultaneous treatment of associated soft tissue injuries, such as meniscal tears, meniscal and inter-meniscal ligament entrapment, interstitial tears of the ACL, and removal of loose fragments. **(5)**

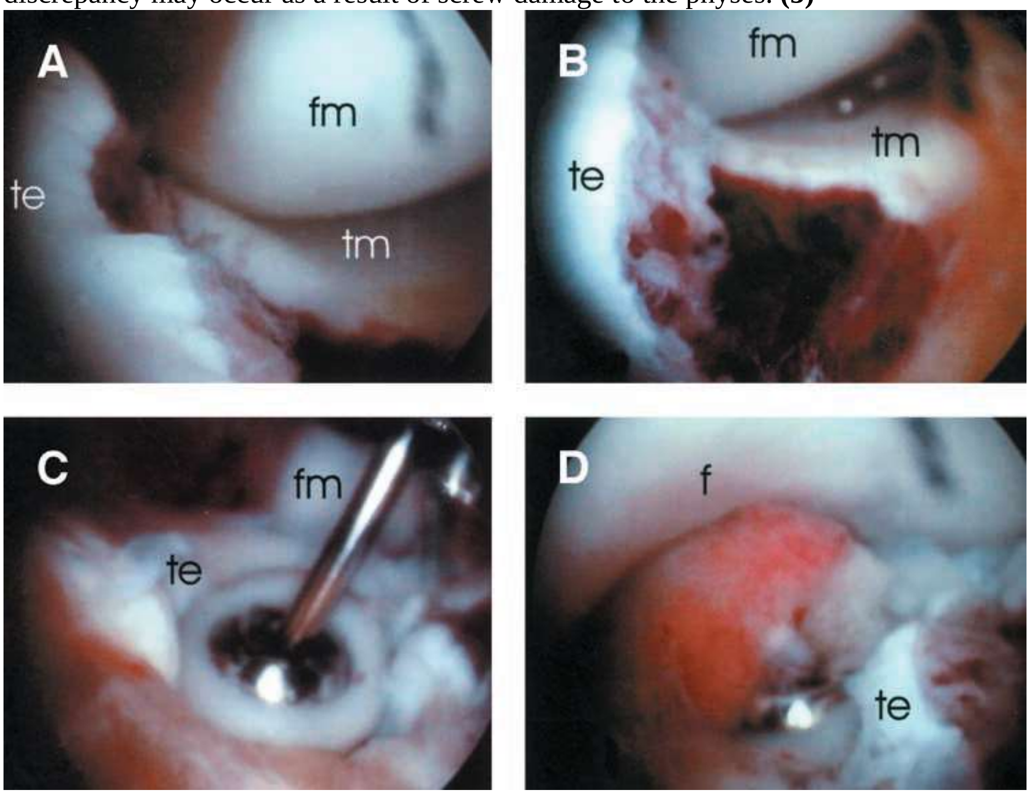
On the other hand, arthroscopy is technically demanding procedure and there is insufficient evidence to support the superiority of the arthroscopic approach in terms of healing, motion deficit, or laxity. **(8)**

- **Arthroscopic methods of fixation:**

1) Screw Fixation:

Screw fixation is an effective and safe surgical option with few complications. Screws can be inserted either retrograde or anterograde. Anterograde insertion is achieved with an aiming guide placed superoanterior to the inferoposterior direction with the knee at 900 of flexion. Retrograde screws are inserted from the anterior cortex of the proximal tibial through the tibial eminence fracture. **(9)**

The screw technique is simple, reproducible, and good fracture repair with almost immediate weight bearing postoperatively, on the other hand there are a few limitations to screw fixation. Cannulated screws may cause anterior impingement, fretting between the washer and screw, and damage of the articular surface, leading to a higher rate of implant removal. Another limitation is the ineffective fixation of small or comminuted fragments where insertion can lead to further comminution or displacement. In skeletally immature patients, growth disturbance and leg length discrepancy may occur as a result of screw damage to the physes. **(5)**

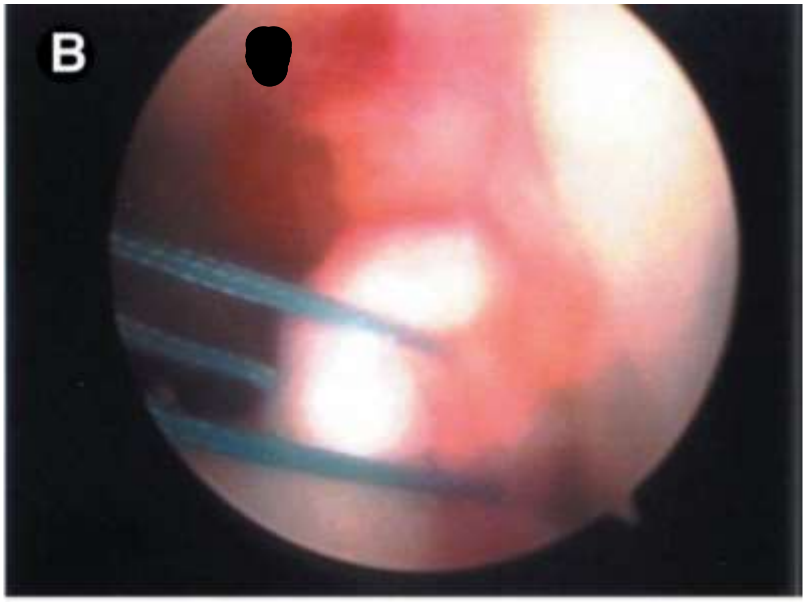


(Fig.1) (A) Fracture of the tibial eminence. (B) The fragment after bed preparation and temporary shift of the anterior intermeniscal ligament for reduction of the fragment. (C) Fixation of the fragment with cannulated screw and washer over the guidewire. The knee is flexed 90°. (D) Position of the screw and washer in extended knee. Abbreviations: te, tibial eminence; fm, medial femoral condyle; tm, medial tibial condyle; f, femur. **(9)**

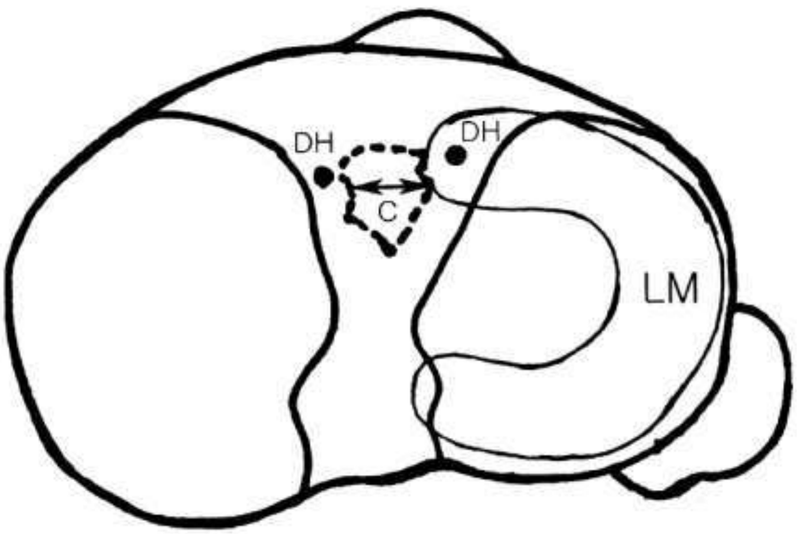
2) Pull out sutures:

Suture fixation methods are fundamentally divided into 2 classes. One is based on the ACL itself (ligament suture methods), and the other is based on the avulsed bone fragment (avulsed bone fragment suture methods). When the fracture of the intercondylar eminence of the tibia is comminuted or small, suture methods based on the avulsed bone fragment are technically impossible. **(10)**

In the ligament suture method, a suture pierces the ACL just above the superior border of the avulsion fragment, purchasing the whole thickness. Two holes were drilled obliquely from proximal anteromedial tibia toward the crater of fracture site. It is crucial to make this hole more anterior than the mid-transverse of the crater. An arthroscopic retriever is introduced to each tunnel, retrieving each end of the suture, and is pulled out to the proximal and anteromedial aspect of tibia, then a sliding knot is made. **(11)**



(Fig.2) Arthroscopic image of sutures being passed into substance of ACL. **(12)**



(Fig.3) Schematic axial drawing of the tibial spine ACL avulsion crater and proper position of the drilled hole.

Suture fixation is suitable for grade IV comminuted fractures or small fragment. suturing technique is able to anatomically reduce and fixate the avulsion. In addition, it is insisted that pulling the inferior portion of ACL fiber by the suture helps to maintain the normal ACL tension. **(13)**

3) <u>K-wires:</u>

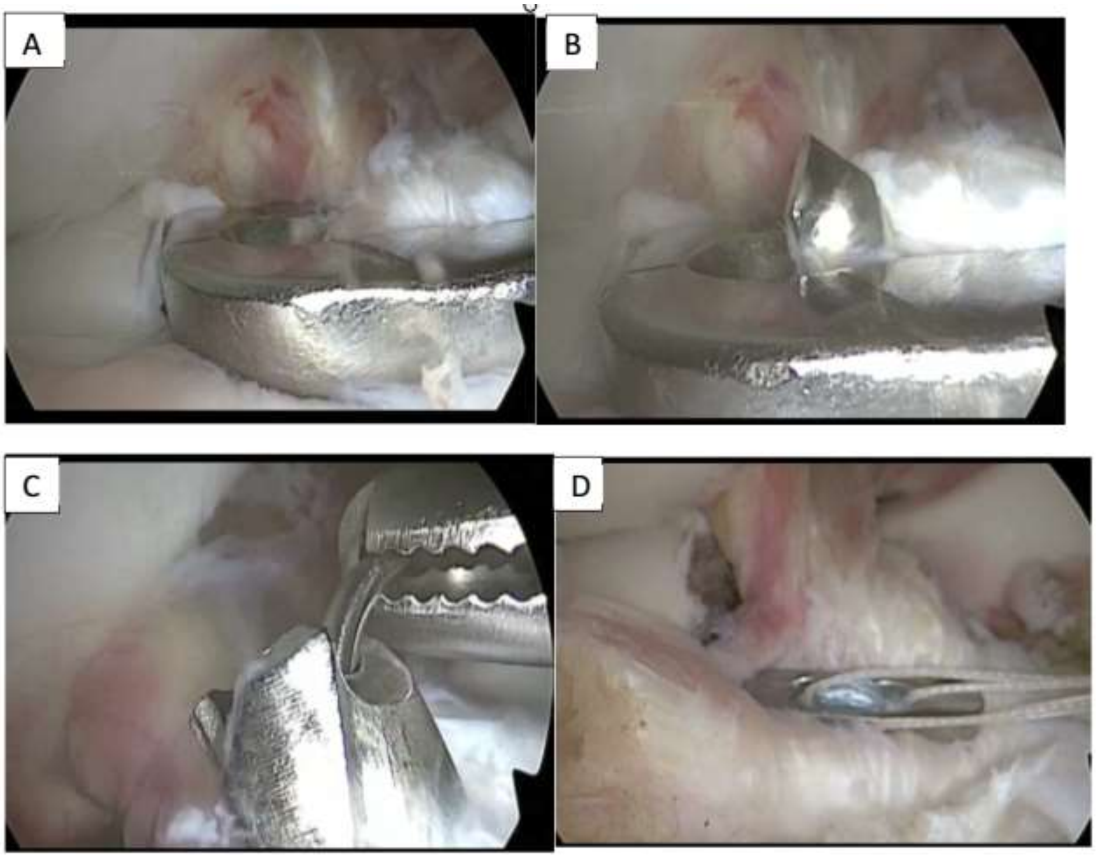
Although it is simple to use, K-wire fixation has difficulty in holding the fragment if the size is small. It is also more troublesome to maintain reduction during early postoperative rehabilitation using this method due to its weak holding power. This fixation method cannot be applied to comminuted type IV fractures. **(13)**

4) <u>Tightrope:</u>

The fracture is reduced and compressed by the hook. A pin guide is introduced through the C-ring drill guide crossing the tibial cortex and terminate in the ACL insertion. It is important not to place the pin too much anteriorly to avoid a tilt of the spine after reduction. The next step is to drill a 4 mm hole along the pin guide. The oblong button is flipped and placed over the tibial eminence. The traction sutures are then tied on the extra-articular round button over the anteromedial tibial cortex allowing reduction and retightening of the ACL. **(14)**

The use of the Tightrope device to treat arthroscopically tibial spines fracture appears to be safe and effective on knee laxity. The technique is straightforward, technically low demand and provides a stable and rigid fixation. **(14)**

Lateral cortical blow out can greatly diminish the strength of fixation for button device. If this happens an implant with a longer button can be used. **(14)**



(Fig.4) **(A)** The C guide hold the reduction and determines the pin placement. **(B)** The pin is then placed in the anterior part of ACL insertion. **(C)** The suture lasso is retrieved out of the cannulated drill with a grasper. **(D)** Flipped and the Tightrope is tightened. **(14)**

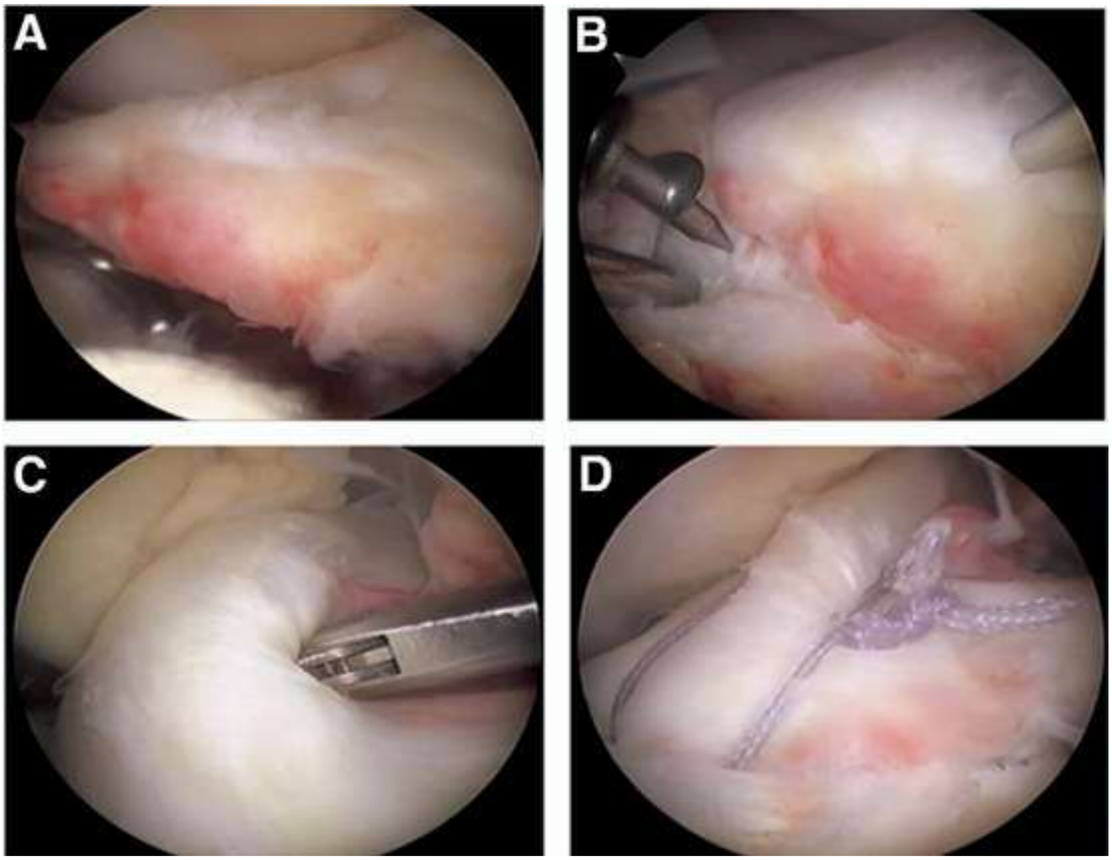
(Fig.5) Postoperative anterior-posterior and lateral view radiographs of a fixed tibial spine using a tightrope. **(14)**

5) Anchors:

Using an anchor passing nonabsorbable braided sutures through the substance of the ACL, holding the avulsed bone fragment by tying a locking knot, and working as a tension band, rather than a direct fixation method. **(15)**

The anchor is placed 2 to 3 mm in front of the fracture rim. The best alignment of the anchor is 45° in the frontal plane. Angulation of the anchor reduces the risk of suture pullout. **(15)**

Suture anchor fixation can be chosen in adolescent tibial eminence fractures because it preserves the proximal tibial physis in skeletally immature patients. However, we would switch to suture fixation during operation if the operative space is too limited. **(16)**



(fig.6) **(A)** Tibial eminence fractures. **(B)** Anchor location with 45-degree angulation. **(C)** Piercing of inferomedial part of ACL with suture hook through anterolateral portal. **(D)** Suture in place.

Rehabilitation

Postoperative rehabilitation programs for tibial spine fractures are widespread and include brace or cast immobilization, immediate or delayed weight bearing, and immediate or delayed ROM. These variables are thought to affect final patient outcome by increasing muscular atrophy, causing cartilage and ligament changes, and leading to stiffness or damage in the joint or decreased ROM secondary to immobilization. **(17)**

For long-term rehabilitation all patients undergo this program, which consists of the following: **- (2)**

(1) Knee immobilization in a posterior slab in extension for 3 weeks, together with isometric quadriceps strengthening and straight leg raising exercises without weight bearing.
(2) Range of motion angle was allowed at 0° to 90° after 4 weeks. and then adjusted to 0° to 120° from 6 weeks.
(3) Partial weight bearing for another 3 weeks with a hinged knee brace with gradual flexion.
(4) Increase the allowed range of motion to 0° to 120° from 6 weeks.
(5) Full weight bearing and a gradual return to activity starting after the end of the second postoperative month.
(6) Patients can resume participating in sports within 4 to 6 months of surgery.

Complications

- **Intraoperative general complications:**

General complications can occur during ligament reconstructive surgery. These include instrument breakage, nerve injury (tourniquet paralysis), vascular injury and anesthesia complication. **(18)**

- **Knee stiffness:**

Diminished range of motion is identified in 60% of patients who are treated for tibial eminence fractures. The most common loss of motion is the inability to achieve the last 5o to 10o of terminal extension. The most important risk factors for significant knee stiffness include having a type III fracture, undergoing reoperation for fixation problems or healing complications, and prolonged immobilization. Early rehabilitation is crucial for all TSAF patients to avoid stiffness . **(19)**

- **Infection:**

The clinical signs of infection 5 days or more after surgery include increased pain, fever, and the persistence of a large effusion. It can be treated by using an appropriate antibiotic according to culture and sensitivity test. **(20)**

- **ACL laxity:**

ACL laxity is common after tibial spine fracture treatment. This complication could be due to stress within the ACL prior to avulsion of the tibial spine which may result in structural damage and functional lengthening despite ligament continuity, but few patients report subjective instability. **(15)**

Although persistent laxity is frequent, it rarely impairs functional outcomes, but some patients will present with symptomatic laxity despite anatomical reduction, requiring subsequent ACL reconstruction. **(15)**

- **Arthrofibrosis:**

Arthrofibrosis is intra-articular scar tissue formation. The exact etiology is unknown, but proposed causes include a genetic predisposition to scar formation, an aberrant inflammatory response to an injury or surgery, or simply prolonged joint immobilization. Arthrofibrosis was defined as a 100 flexion contracture or a flexion loss of 250 at least 3 months postinjury and after completing a formal physical therapy regimen. **(19)**

When arthrofibrosis is encountered, dynamic splinting has been successful as an adjunct to physical therapy. If splinting is unsuccessful, surgical treatment with appropriate rehab can also improve ROM. **(11)**

- **Growth disturbance:**

In skeletally immature patients, care must be taken not to traverse the proximal tibial growth plate with fixation devices because of the risk of partial physeal arrest causing iatrogenic growth disturbances. **(9)**

- **Impingement:**

The screw technique may cause anterior impingement and need to be removed in another session. **(9)**

- **Effusion:**

The effusion commonly occurs in the early postoperative period and persists for the first 4 to 8 weeks. Most effusions can effectively be treated with ice, elevation, and compression. **(18)**

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