Knee Fractures

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Basics of Fractures

Description of Fractures

In this chapter, we will discuss common fractures that occur around the knee. A fracture occurs when external stress on a bone exceeds the bones strength.

In general, displaced and/or open fractures will require surgery and non-displaced and/or closed fractures can be managed non-operatively.

Fracture Healing

There are three stages of fracture healing; inflammation, repair, and remodeling (factors that influence healing). The whole pro-

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cess of fracture healing takes anywhere from 4 to 12 weeks. The inflammatory stage starts from the time of initial injury to 2 weeks, when callus formation has started. The fracture callus ossifies in weeks 2–4 which denotes the repair stage. Finally, the remodeling stage is when woven bone replaces trabecular bone and starts during the repair stage but can last up to 12 weeks [1].

Fracture/Displacement Types

The two most important aspects of any fracture are the fracture location and fracture morphology. To be able to fully assess the location and morphology of any fracture, an X-ray of the suspected region is imperative. For fracture location, you will need to identify which bone is fractured, if it is distal or proximal and what part of the bone is affected. For long bone fractures, it is important to identify what region of the bone is effected; the epiphysis, diaphysis or metaphysis.

After identifying the location of the fracture, the morphology of the fracture will help determine the severity of the fracture. The morphology of the fracture is often used to determine whether the fracture is operative or non-operative. For long bone fractures along the diaphysis, there are three types of morphology: simple, wedge, and multifragmentary. Simple fractures are classified as either spiral, oblique or transverse; wedge fractures consist of an intact wedge or fragmented wedge fracture; and multifragmentary fractures consist of multiple fracture lines and consist of either intact segmental or fragmented segmental fractures. Fractures that involve the metaphysis or epiphysis have different morphology. The most important factor before determination of morphology is whether the fracture is intra- or extra-articular. Extra-articular will consist of avulsion, simple, wedge, and fragmented fractures. Partial and complete intra-articular fractures are further classified as simple, split, depressed and multifragmented [1].

What Needs Immediate Orthopedic Surgery Referral

Compartment Syndrome

There are four different compartments in the leg that have rigid fibro-osseous borders. Compartment syndrome is caused by increased pressure in one or more of these compartments. Compartment syndrome can occur with any fracture in or around the knee discussed in this chapter [1]. The most common involved compartment is the anterolateral compartment. Compartment syndrome requires immediate surgical referral for emergent fasciotomy. It is important to understand how to assess for compartment syndrome to help get the patient a surgical referral as quickly as possible.

The most commonly used method to diagnose compartment syndrome is commonly remembered as the five "P's" [2]:

1. Pain with passive stretch.
2. Paresthesia.
3. Pallor.
4. Pulselessness.
5. Paralysis.

Concern for Arterial Damage

It is imperative to check pulses distal to the fracture. The dorsalis pedis pulse is the most common pulse evaluated, but you can also palpate for the posterior tibialis artery as it courses through the tarsal tunnel just about the ankle.

Concern for Nerve Damage

If there is decreased or no movement in the lower extremity with the associated fracture and/or decreased/no sensation, this will require immediate orthopedic surgery referral to evaluate for possible nerve damage.

Physical Examination for All Fracture Types

Evaluate the skin to look for abrasions or tears that may indicate an open fracture. Evaluate for effusion, if this is present, this could indicate osteochondral or ligamentous injury [3].

Evaluate for compartment syndrome above. Distal pulses (tibialis posterior and dorsalis pedis) must be tested. If not present, may consider Doppler to evaluate for blood flow or immediate orthopedic surgical referral. Sensation to the ipsilateral lower extremity, if decreased, there is likely nerve damage that will require immediate surgical intervention.

Phases of Rehabilitation

1. *Resolve pain and inflammation*: This first stage of rehabilitation is focused on recovery and minimizing further damage done to tissues. Different modalities that will help in this process include ice, limiting aggravating activities, NSAIDs, ultrasound, and electrical stimulation.
2. *Restore range of motion*: After the patient has shown recovery from initial injury, it is time to start restoring function. The first part of restoring function will be focusing on returning to pre-injury range of motion. In this stage, it is important to perform gentle range of motion exercises and stretching to not overexert the injured body part but also to help limit decreased range of motion long term.
3. *Strengthen*: Muscle strength is often lost during the recovery phase due to disuse of the injured body part. Once full range of motion is obtained, the focus turns to strengthening the muscles that were affected from the injury. Weight machines are

incredibly beneficial in this stage as they help patients focus on strength training exercises of specific weakened muscles while limiting riskier strength training activities that can aggravate injuries.

4. *Restore function*: The last stage of rehabilitation involves returning patients to their prior level of function. This phase will focus on coordination, balance, agility, change-of-direction capability, and rate of force development. Each of the aforementioned qualities will vary greatly depending on if you are returning a patient to a sport-specific activity versus returning them to performing their activities of daily living.

Common Fractures

For the rest of this chapter, we will discuss the different types of knee fractures, mechanism of injury, physical exam findings, diagnostic imaging, treatment, and return to activities.

Patellar Fractures

Overview

Patella fractures are uncommon and typically occur in patients aged 20–50 years of age. The most crucial aspect when diagnosing patella fractures is determining the integrity of the quadriceps tendon. Non-displaced fractures and those with intact knee extension heal well with immobilization and rehabilitation. As is common in most pediatric cases, patella fractures in children are typically avulsion or osteochondral fractures [3].

Types of patellar fractures include osteochondral, transverse polar, vertical comminuted, medial avulsion, lateral shear, central shear, and non-displaced avulsion fractures of the patella which may occur after a lateral patellar dislocation [3]. Transverse fractures are the most common type of patellar fracture [3]. Most patella fractures are due to direct forces such as a fall on the anterior aspect of the knee or striking the knee on the dashboard in a motor vehicle accident [3]. The quadriceps muscle can also contract forcefully causing a patellar fracture.

Clinical Presentation

Typically occurs from a direct blow to the knee but can occur from excessive quadriceps force. There will be immediate tenderness and swelling over anterior knee.

Physical Exam

If fracture is displaced, a defect can be felt if no significant swelling is present.

Patient will be unable to actively extend the affected knee; to test, the patient will lay supine and actively extend the affected leg 6 inches. If unable to do so secondary to pain, provider may consider injection of local anesthetic to test full knee extension capabilities.

Diagnostic Studies

- X-rays: AP, lateral, and sunrise view of the knee. The lateral view is the most useful view in delineating fracture lines and determining displacement [3].
- MRI and CT scan are rarely used for patellar fractures but can be utilized to evaluate for suspected soft tissue injury or injury to the quadriceps extensor mechanism.

A separation of more than 3 mm between fragments or an articular step off of more than 2 mm constitutes a displaced fracture [3]. This is important as it dictates whether the fracture is non-operative vs. operative.

Treatment

Urgent: Any avulsion fractures that involves the quadriceps and patellar tendon and any open fracture [3].

Operative: Severely comminuted fractures and displaced patellar fractures >3 mm between fragment or >2 mm articular step off.

Non-operative: Non-displaced patellar fractures that have a smooth articular surface with an intact quadriceps mechanism, and who are capable of extending the knee against gravity [3].

For immediate management, the knee should be placed in an immobilizer in full extension with compression and ice. Non-weight bearing status should be maintained for 5–7 days until

follow-up. Once swelling has stabilized (generally 5–7 days), a cylinder cast should be utilized for 4–6 weeks. The cast will need to go from the groin to just above the ankle malleoli with the knee in extension [3].

Non-displaced marginal vertical fractures do not have to be immobilized and can be treated with reduced activity for 3–6 weeks and progressive ROM and strengthening exercises [3].

Return to Activities

Work:

Sedentary jobs: Patients can return within a couple days for non-operative management but may be best to wait 5–7 days for initial follow-up.

Active jobs: May return after cast/brace removed and have begun functional range of motion (4–6 weeks).

Sports:

Non-operative management will be a minimum of 4–6 weeks until immobilizing cast/brace is removed. At this point, patients will gradually progress with therapy focusing on range of motion and strength training. Patients may return to full activity participation when asymptomatic.

Patellar Dislocation

Overview

Patella dislocation occurs when the patella is displaced outside of its position in the vertical groove of the knee.

Predisposing factors to patellar dislocation include obesity, young female, shallow femoral groove, joint laxity, high riding patella, genu valgum, external tibial torsion, and atrophy of the vastus medialis [4].

Dislocation of the patella typically occurs with an external pivotal motion on a partially flexed knee followed by a forceful contraction of the quadriceps that pulls the patella laterally (e.g., swinging a baseball bat, quick lateral change of direction when running) [3]. Patellar dislocation can also occur from a direct blow to the medial patella, forcing it laterally, though this is less common [3].

Clinical Presentation

Patients often present post-dislocation reduction with anterior knee pain. If patella is still dislocated on presentation, patient will maintain knee at 20–30 degrees of flexion with an obvious deformity and palpable patella laterally [3].

Physical Exam

Most of the exam findings will be along the medial aspect of the knee. Tenderness to palpation is typically found along the medial patella edge or proximal to the medial femoral condyle. A hemarthrosis can often be appreciated as well; a larger hemarthrosis volume (50 mL) suggests a more major injury to the medial stabilizers or osteochondral injury and is associated with a lower recurrence rate [3].

Diagnostic Studies

X-rays should be obtained to rule out an associated fracture even if the patella spontaneously reduced. The AP and lateral views should be examined, particularly for an osteochondral fracture of the patella, which occurs in up to 40% of cases [5].

Treatment

Urgent: Those that cannot be reduced or rare patellar dislocations (superior, inferior, or medial) require prompt orthopedic referral.

Non-operative: Initial treatment includes limitation of knee flexion with a knee immobilizer, icing, and elevation of the knee. The patient should remain non-weight bearing until seen for the initial follow-up visit in 2–3 days [3]. Early rehabilitation with emphasis on range of motion is imperative. Patients should be provided with a patellofemoral brace to be worn in the initial post-injury phase. Patients should be referred for physical therapy to focus on quadriceps strengthening. Patients should limit walking, standing, and repetitive bending.

There is conflicting reports on the benefits of operative versus non-operative management for first time dislocators [6].

Return to Activities

Work:

Sedentary: Patient is able to return to work within days as tolerable.

Active jobs: Similar to return to sport as below but will be adjusted depending on the level of activity at work.

Sports:

The criteria for return to sport is now based on clinical criteria versus weeks to months. The following must be obtained before return to sport; (1) no pain; (2) no effusion; (3) no patellofemoral instability; (4) a full range of motion; (5) nearly symmetrical strength compared to uninjured side (85–90%); and (6) excellent dynamic stability. The typical timeline to return is 6 weeks after a dislocation with non-operative management, and 3 months with operative management [7].

Tibial Plateau Fractures

Overview

The tibia is the most frequently fractured long bone. Many tibial plateau fractures are a result of a car-pedestrian accident where the bumper strikes the outside of a patient's leg with a force directed medially. Because the lateral plateau is weaker than the medial plateau, the majority of tibial plateau fractures will result in a depressed or split fracture of the lateral tibial plateau. Fractures of the medial plateau suggest a higher energy force (varus) because of the greater strength of the medial plateau. Elderly, osteoporotic patients are more likely to sustain a fracture of the tibial plateau than a ligamentous or meniscal tear after a twisting injury to the knee. Associated injuries include intercondylar eminence fractures and ACL tear as a result of hyperextension or rotatory forces [3].

It is important to get near anatomic alignment of these fractures due to the increased risk of nonunion and malunion in these fractures. Minimal displacement in tibial fractures require referral to an orthopedic surgeon [3].

Clinical Presentation

Patients with tibial plateau fractures will have a painful swollen knee and are unable to bear weight on the ipsilateral leg.

Physical Exam

Tenderness over the proximal tibia and limited flexion and extension of the knee. To ensure a more thorough knee exam, aspiration of effusion and injection of local anesthetic are indicated. Test the stability of the knee by stressing the knee in varus and valgus throughout range of motion; a stable knee will have less than 10 degrees of joint widening on varus and valgus stress from full extension to 90 degrees of flexion. The ACL should also be examined as it is commonly injured in this type of fracture [3].

Diagnostic Studies

- X-ray*:* AP, lateral, and intercondylar notch views of the knee.
- Fracture types: [2]
  - Type 1: Lateral plateau split fracture.
  - Type 2: Lateral split/depression fracture.
  - Type 3: Lateral plateau depression.
  - Type 4: Medial plateau split fracture.
  - Type 5: Bicondylar plateau fracture.
  - Type 6: Fracture with metaphyseal-diaphyseal separation.
  - Type 4–6 Typically result from high-energy trauma.
- CT Scan:

  If plain radiographs above are equivocal but there is still high clinical suspicion for a fracture, additional imaging using a CT scan is warranted. MRI has become more advantageous due to its superior ability to detect associated ligamentous and meniscal injuries [3].

Treatment

Urgent: A significantly comminuted, open fracture associated with vascular injury, compartment syndrome or knee dislocation require emergent surgery [3].

Operative: X-rays with greater than 3 mm step off and less than 5 mm gapping.

Non-operative management: Patient's knee should be immobilized in a long-leg splint from the thigh to the metatarsals in full extension and the ankle at 90°. This can be transitioned to hinged brace at full extension with gradual flexion adjustment from 0 to 4 weeks. At 4 weeks, 90 degrees of flexion is allowed; if not obtained at 4 weeks, physical therapy is indicated [3].

Along with the above weekly hinge adjustments, weekly knee X-rays should be obtained to ensure correct bone healing and alignment (if malalignment, patient should be referred to specialist immediately for correct alignment).

Non-weight bearing status is maintained for at least 6 weeks, until bone healing is appreciated, and partial weight-bearing with crutches until bone healing appears complete on radiographs (8–12 weeks).

Hinged brace use should continue until 8–12 weeks, whenever union of the bone is achieved.

Operative management: Any displaced or depressed tibial plateau fractures with associated ligamentous or meniscal injuries should be referred to an orthopedic surgeon [3].

Return to Activities

Work:

Sedentary jobs: Once a patient begins flexing the knee and becomes partial weight bearing (around 6 weeks) working full time should be manageable. Returning to work earlier can be achieved depending on pain tolerance.

Active jobs: These may be gradually resumed after a solid union is present and full weight bearing is well tolerated [3].

Sports:

Athletes should be able to safely resume non-weight bearing aerobic activities such as swimming or biking after full weight bearing is started. Sports specific activity will then gradually progress based on the patient's tolerance.

Tibial Shaft Fractures

Overview

Tibial shaft fractures occur as a result of three types of mechanisms: 1) Low-energy forces such as a sports injury, 2) Rotational forces on a fixed foot 3) High-energy forces such as falls from a significant height [3]. Low-energy injuries typically lead to distal fractures, whereas high-energy injuries typically lead to proximal fractures. Oblique and spiral fractures occur as a result of indirect forces, whereas transverse and comminuted fractures occur as a result of direct trauma. The degree of comminution is usually proportional to the amount of energy that caused the fracture. The anteromedial aspect of the tibia is at higher risk of fracture from direct blow due to its relatively superficial position [3].

Clinical Presentation

Inability to bear weight and significant pain over the fracture site.

Physical Exam

Swelling and obvious deformity of tibia typically seen (unless non-displaced).

Open fractures are common in these types of fractures so thorough skin evaluation is imperative. Dorsalis pedis and tibialis posterior pulses should be identified and examined. Tibial shaft fractures are one of the most common causes of compartment syndrome, so prompt evaluation is a must (please see beginning of chapter for more detail on compartment syndrome).

Diagnostic Studies

- *X-rays:* AP and lateral views of the entire tibia, including the knee and ankle joints, should be obtained.
- *MRI and CT* are typically not indicated for tibia shaft fractures unless arterial damage is suspected [3].
- Fracture type: [2]
  - Transverse fracture (fibula intact).
  - Spiral fracture with shortening.
  - Comminuted fracture with marked shortening.
  - Segmental fracture with marked shortening.

A tibia shaft fracture is considered non-displaced if it meets the following criteria: less than 5 mm of displacement and less than 10° of angulation in both the AP and mediolateral planes, and less than 10° of rotation [3].

Treatment

For all treatments of tibial shaft fractures, patient will need to be immobilized and placed in a long-leg splint.

Urgent: Any fracture that is open has neurovascular injury, or knee/ankle dislocation requires immediate orthopedic surgery referral.

Operative: Comminuted and segmental fractures.

Non-operative: Non-displaced fractures as described above. The leg should be immobilized in a long-leg posterior splint from the metatarsals to the upper thigh, with the knee in 10–15 degrees of flexion and the ankle at 90° [3]. Patient must remain non-weightbearing and consideration for hospitalization for observation may be warranted in cases with higher concern for compartment syndrome.

Circumferential cast applied after swelling has decreased (typically 3–5 days). To prevent excess motion above and below the fracture, the cast should extend from the thigh to the metatarsal heads [3].

Return to Activities

Return to work or sports depends on the severity of the injury.

Work:

Sedentary jobs: Able to return as soon as the long-leg cast is discontinued.

Active jobs: Similar to return to sport as below but will be adjusted depending on the level of activity at work.

Sports:

Non-weight bearing activities initially when out of the long-leg cast followed by progressive supervised rehabilitation

for several months to restore motion and strength. Return to full activity depends on the severity of the fracture and any associated injuries.

Proximal Fibular Fractures

Overview

Isolated proximal fibula fractures are uncommon and are typically associated with more serious injuries. Fibular fractures are caused by a direct blow to the lateral leg but can also occur from an avulsion of the lateral collateral ligament or significant external rotational force about the ankle (The Maisonneuve fracture). In order to distinguish complicated from uncomplicated fractures, the practitioner will have to recognize compartment syndrome or any neurovascular and ligamentous injuries [3].

Clinical Presentation

Patient will have lateral knee pain along the fracture site that may span the length of the fibula with diffuse swelling and effusion on initial assessment. Lateral compartment syndrome uncommon but can occur with crush injuries [3].

Physical Exam

Testing the actions of the peroneal nerve including dorsiflexion and plantarflexion of the ankle. Evaluate for paresthesias over the lateral aspect of the middle to distal leg and dorsum of the foot. Dorsalis pedis and posterior tibial artery will need to be palpated. Will also need to investigate the integrity of the interosseous membrane.

Diagnostic Studies

- *X-rays*: AP and lateral views of the entire fibula.
- MRI and CT are only utilized if associated arterial or ligamentous is suspected.

Treatment

Initial immobilization in a long-leg knee immobilizer in near full extension should be used until the patient is seen by the orthopedic surgeon. Isolated fractures of the fibula shaft heal well with minimal treatment and are treated symptomatically.

Urgent: Crush injuries, open fractures, associated tibial fracture, compartment syndrome, or peroneal nerve injury involvement all require immediate orthopedic surgery consultation.

Operative: Patients with displaced or comminuted fractures, fractures with concomitant knee or ankle joint instability, and proximal head or neck fractures must be referred to an orthopedic surgeon [3].

Non-operative: Non-displaced fractures, a patient with an isolated fibular fracture should be placed in a stirrup splint with the ankle at 90°. Patients will need to remain non-weight bearing until follow-up, typically around 3–5 days.

A short-leg walking cast or cast boot is indicated for relief of moderate-to-severe pain and should be applied for 3–4 weeks. At this point patients can move to an as-needed splint with full healing of the fracture expected around 6–8 weeks [3].

Return to Activities

ROM and calf strengthening exercises should be started after immobilization period (3–4 weeks).

Work

Sedentary jobs: May return to work within 1-week post-injury.

Active jobs: Return to work after rigid immobilization cast removed (3–4 weeks).

Sports:

Athletes can return to high-level sports as soon as they have near-normal ankle motion and lower extremity strength [3].

Stress Fractures

Overview

Stress fractures are relatively common overuse injuries seen in athletes, particularly in running athletes. Stress fractures account for 0.7–20% of all sports medicine clinic injuries [8]. Tibial stress fractures are more common than fibular stress fractures.

Most studies of stress injuries cite some alteration in the training program as the most significant factor in producing the injury. It has been well documented that there is an increased injury rate with increasing distance beyond approximately 32 km/week. Hard training surfaces play a role in acceleration of stress fractures [8].

Clinical Presentation

Patient presents with pain after or toward the end of physical activity at the location of the stress injury, which is in contrast to ligamentous injuries which occurs at the beginning of physical activity and lasts longer [8].

Physical Exam

The most pertinent and typically only physical exam finding is focal tenderness and swelling at the site of the stress fracture.

Diagnostic Studies

- *X-rays*: Typically stress fracture is not evident within the first 2–4 weeks after fracture. Localized periosteal thickening, cortical sclerosis, or a true fracture line are positive findings of tibial shaft stress fractures [3].
- *MRI*: This is the gold standard for identifying stress fractures. Useful in distinguishing soft tissue injuries and shin splints from stress fractures [3].

Treatment

Stress fractures are non-urgent and non-surgical unless the stress fracture leads to a full tibial shaft fracture (refer to above section for this scenario).

Operative: As above, these injuries are non-surgical.

Non-operative: The initial treatment is rest and immobilization in a long air splint or hinged knee brace for 1–2 weeks. The patient should remain non-weight bearing as long as there is pain with walking. Once the patient can walk with little to no pain, only partial use of crutches is needed followed by progression to unassisted ambulation [3].

Return to Activities

Work:

Sedentary jobs: May return as soon as pain is controlled.

Active jobs: May return to work within a few weeks with an air splint.

Sports:

May return to full activity around 8-weeks post-injury.

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