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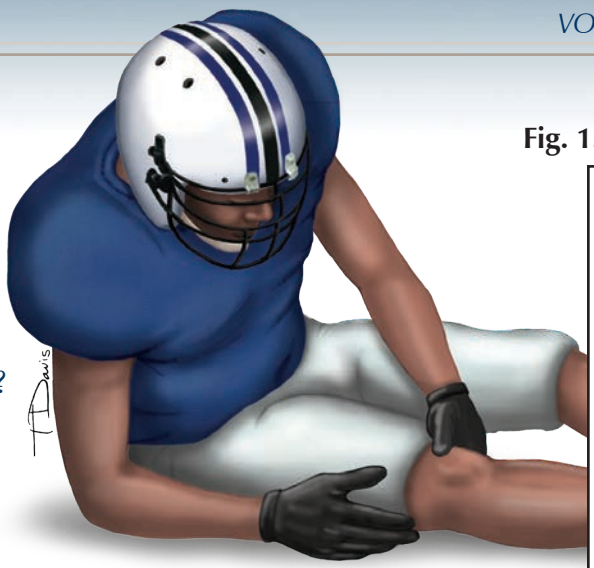
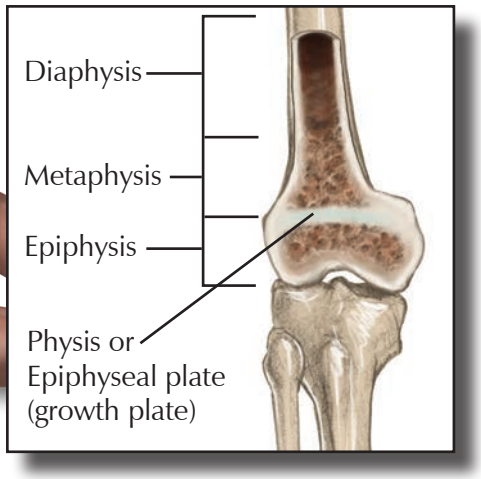


Fig. 1. Normal anatomy of a child's femur



Growth Plate Fractures of the Femur:

DISTAL FEMORAL PHYSEAL FRACTURES

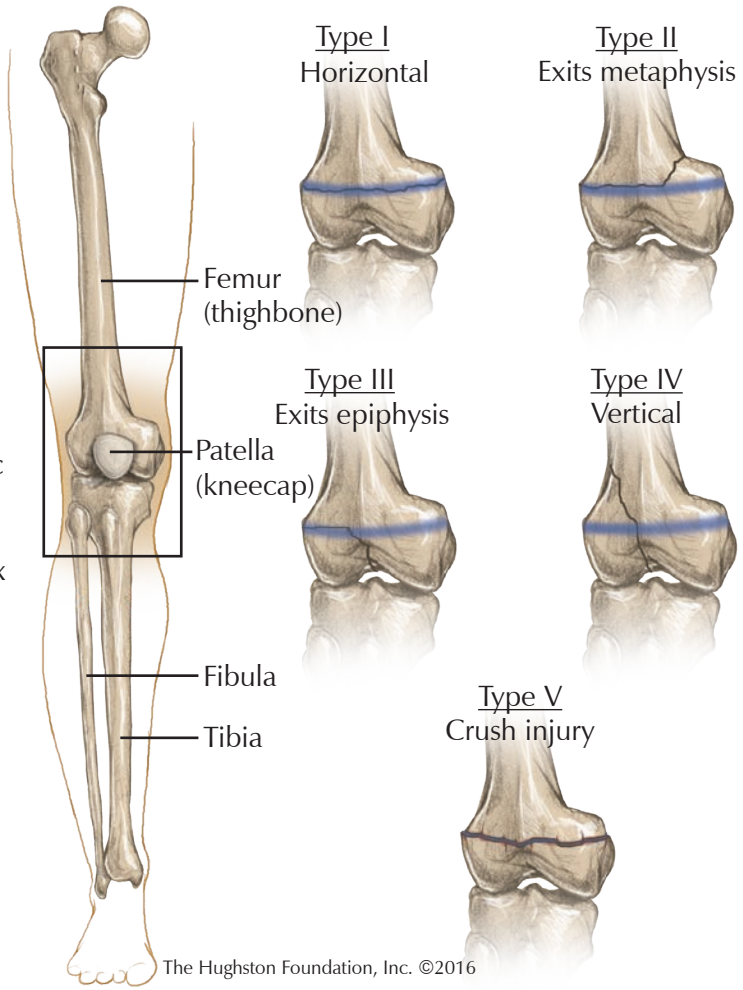
The thought of a broken bone makes most people cringe, but the reality of a broken bone in a child is enough to make most parents sick. So many questions come to mind: Will his leg be straight? Will she ever walk again? Will he have a permanent disability? While more than likely the youngster will recover fully, when a growing child fractures a bone, it does raise concerns that do not arise when an adult breaks the same bone.

As participation in youth sports and the number of child athletes have increased, so has the number of sports-related injuries. According to the American Association of Orthopaedic Surgeons, the knee is the most commonly injured body part in young athletes. Injury to the knee can vary from simple soft tissue injuries—such as lacerations or bruises—to more complex ones—such as strains or tears of the muscles and tendons—or to fractures of the bones that make up the joint. One type of fracture is a distal femoral physeal fracture, an injury involving the growth plate at the end of the femur (thighbone).

The physis or epiphyseal (growth) plate

A growing child's knee differs from an adult's, and these differences put him or her at risk for certain types of injuries. Most notably, at both ends of the femur, as with the ends of all long bones, a child has a growth or epiphyseal plate, called the physis (the word for growth in ancient Greek) where the bone

Fig. 2. Normal anatomy and Salter-Harris 5 types of distal femur fractures



grows lengthwise. The growth plate is sandwiched between 2 other sections of the bone: the epiphysis, or rounded end of the bone, and the metaphysis, a short section that extends upward into the diaphysis or long shaft of the bone (**Fig. 1**).

The growth plate consists mainly of hyaline (transparent) cartilage produced by specialized cells called chondrocytes. This cartilage has a pearly surface and a firm consistency that, with the addition of calcium and phosphorus, calcifies and then ossifies to form bone tissue. Although the physis is complex, consisting of multiple layers, it is nevertheless a relatively weak area of bone. The physis is not only weaker than the other areas of the bone, but, when it comes to the femur, it is also weaker than the ligaments that surround the knee. This explains why a physeal injury in the growing child is more common than a ligamentous injury. Overall, physeal fractures make up 15% of all childhood long bone fractures. Moreover, growth plate fractures occur twice as often in boys as in girls largely because in most girls the growth plates are replaced with solid bone sooner than in boys.

Classifying physeal fractures

Physeal fractures are distinct enough to have their own separate classification system. In 1963, physician-researchers Robert B. Salter and W. Robert Harris described 5 main types of physeal fracture patterns. In the Salter-Harris classification, type I represents a simple horizontal fracture of the physis or growth plate. Type II involves a fracture through the physis that exits out the metaphysis, and it is the most common type of physeal fracture. A type III fracture, by contrast, exits out the epiphysis, and thus involves the joint. A type IV fracture also involves the joint, but is more vertical, spanning the epiphysis, physis, and the metaphysis. Finally, although it can look much like a type I injury, a type V fracture constitutes a crush injury of the physis and is associated with long-term damage to the growth plate (**Fig. 2**).

Diagnosing distal femoral physeal fractures

Examination of a child with a distal femoral physeal fracture will frequently reveal a swollen knee with a significant amount of blood accumulated in the joint. The knee will be tender to the touch, and the broken bones rubbing against each other will cause a grinding sensation. Depending on the degree of displacement of the fracture, an obvious deformity may also be observed. Additionally, the physician will check to see whether nerves or blood vessels have been damaged, especially if the joint has been hyperextended (overextended). Identifying the exact type of physeal fracture can be difficult, particularly when it comes to type V fractures, as complications from the injury to the growth plate do not usually arise until later on.

Treating distal femoral physeal fractures

Treatment for a distal femoral physeal fracture depends on its type. Nondisplaced fractures remain in normal anatomical position: they do not require manipulation and are immobilized in a cast. In cases of displaced Salter-Harris I and II fractures, the bone that has moved from its normal position must be manipulated back into alignment before a cast can be applied. Most of these injured bones will remain well aligned in the cast and can be successfully treated without surgery. However, 20% of these cases will require surgery because the bone cannot be manipulated back into normal alignment or it shifts in the cast. During surgery, pins are inserted into the broken bone to hold it in position until it has healed.

Displaced Salter-Harris III and IV fractures involve the joint surface. If this surface is no longer smooth and continuous, long-term damage can occur. Thus these types of fractures must usually be surgically realigned. After the fracture is in the correct position, it is held in place with pins that will be removed once the injury has healed.

A type V fracture, by contrast, is a crush injury in which the blood supply to the growth plate is disrupted, causing the cartilage to die. Since there is generally minimal displacement of the bone and growth arrest is only discovered months later, it is initially the hardest to diagnose of the fracture types. The resulting deformity will require surgery to realign the epiphyseal plate and immobilization to protect the fracture while healing.

Long-term consequences

Growth plate damage that occurs at the time of injury does not always manifest in the early stages of treatment. The damage can present 6 to 12 months after the original injury; therefore some physicians recommend follow-up for a full 2 years to ensure normal growth and alignment. If the physis is completely damaged, such as with a type V physeal fracture or crush injury, the injured limb may end up shorter than the unaffected one. If it is partially damaged, only one side of the bone may continue to grow, resulting in an angular deformity. Shifting of the fracture in a cast or after the surgical placement of the pins can also lead to an angular deformity. It is therefore important to identify a poorly positioned fracture early on so it can be properly repositioned before it heals. This means that in the early stages after treatment of a distal femoral physeal fracture, there should be frequent follow-ups with repeat x-rays.

General outcomes

The outcomes for distal femoral and other epiphyseal fractures are generally favorable; however, such fractures can be serious. Salter-Harris types I and II fractures are the least likely to result in long-term growth problems or to require surgical intervention. Types III, IV, and V are more likely to cause growth-related issues and may require surgery to improve outcomes. While growth plate injuries do raise concerns, with prompt diagnosis and strict adherence to physician's instructions, children usually recover fully.

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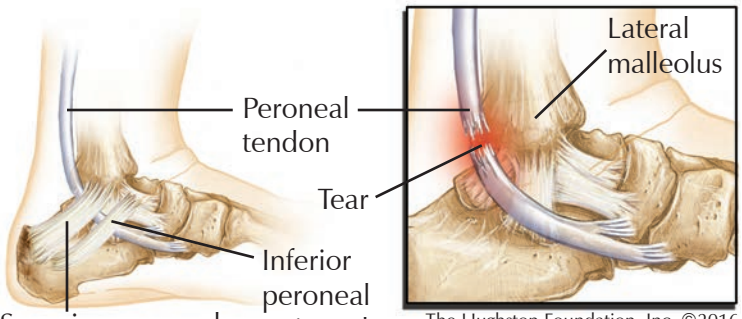
Peroneal Tendon Injuries

Tendons are tough, white fibrous tissues that connect muscle to bone. When a muscle contracts, it pulls on its associated tendon which then moves the bone. Two tendons, the peroneus longus and peroneus brevis, originate in the lateral (outside) compartment or group of muscles of the lower leg and run alongside each other in a sheath on the outside of the ankle joint. Encased in this sheath, both tendons sit within the fibular groove behind the ankle, which is surrounded by several ligaments (tissue that connects bone to bone) and a retinaculum, a fibrous band that passes over the tendons and holds them in place (Fig. 1). Once the tendons pass the ankle joint, the sheath splits as each tendon extends distally (downward). The peroneus brevis tendon then attaches to the outer portion of the foot while the peroneus longus attaches to the underside of the foot's arch. Both tendons are involved in eversion, or turning the ankle to the outside, and function primarily to stabilize and protect the ankle from injury.

Fig. 1. Peroneal tendon: normal anatomy & tear



Types of peroneal tendon injuries

Common types of peroneal tendon injuries include tears, tendinitis, and subluxation. All 3 can result from either acute (sudden or traumatic) or chronic (recurrent) ankle sprains (stretching or tearing of the ligaments that support either side of the ankle). Thus, a likely candidate for a peroneal tendon injury is someone who participates in sports that involve repetitive ankle movements and where ankle sprains are common, such as soccer or long-distance running. As the player's or runner's foot rolls inward, the forceful stretch can cause not only an inversion (inward turning) sprain on the lateral side of the ankle, but also a strain or tear of the peroneal tendons.

By contrast, peroneal tendinitis is inflammation resulting from microtears of 1 or both tendons due to repetitive use, overuse, or trauma. Patients suffering from peroneal tendinitis typically complain of pain and swelling on the outside of the lower leg or weakness in the motion of the foot while walking or playing sports. If tendinitis becomes chronic, the tendon can degenerate, resulting in a condition called tendinosis.

Another condition called subluxation occurs when the peroneal tendons slip out of normal position within the fibular groove. Patients with subluxation complain of a "snapping" sensation near the ankle accompanied by pain, swelling, and weakness. This "snapping" is the result of the tendons slipping out of the groove. This can happen if the patient has a variation in the shape of either the peroneus muscle or the lateral malleolus (outer ankle bone), or, alternatively, has a high arch. More often, however, subluxation is the result of a trauma, such as an ankle sprain. Damage to the retinaculum that holds the tendons in the proper anatomical position behind the ankle can lead to chronic subluxation.

How are peroneal tendon injuries diagnosed?

As peroneal tendon injuries are not all that common, they are often overlooked. A typical scenario is when a patient fails to recover fully from an ankle sprain. The orthopaedic physician will then examine the foot and ankle looking for tenderness upon palpation as well as swelling, instability, and weakness on the outside of the ankle along the peroneal tendons. If subluxation is present, this can usually be visualized and palpated during a physical examination. In these cases, imaging studies such as x-rays are usually negative for acute findings; however, magnetic resonance imaging (MRI)—a scan that uses radio waves and a strong magnetic field to visualize cross-sections of soft tissue—can diagnose a tear or inflammation within the peroneal tendons.

How are peroneal tendon injuries treated?

Peroneal tendon injuries are treated according to their type and degree of severity. Acute injuries and ankle sprains are initially treated with RICE (Rest, Ice, Compression, and Elevation), oral anti-inflammatory medication, and immobilization (**Table**). While applying ice helps reduce the initial swelling from the injury, taking medication helps reduce the pain and inflammation. Immobilization along with rest prevents further injury and allows tissues to heal. Treatment modalities such as physical therapy are important for increasing strength, proprioception (the ability to sense stimuli having to do with body position), and range of motion in the joint. These methods of conservative management usually permit the patient to return to his or her pre-injury activity level. Patients who are involved in activities that require repetitive ankle movement may also benefit from having their ankles braced.

If a peroneal tendon tear has been diagnosed and conservative management has not been effective, the patient may need surgery. Simple tears can be repaired using sutures. Occasionally, however, tears in the peroneus brevis tendon can cause it to lose its natural tubular form and flatten out; when this happens, the tendon cannot glide smoothly along the fibular groove. Surgical intervention involves repairing the tendon and restoring its tubular shape. When tendon tears are complex, make up more than

RICE (*R*est, *I*ce, Compression, *E*levation)

Essential elements for managing pain and swelling

- **Rest** from your activity to allow the affected area to heal and to avoid further trauma to the injury.
- **Ice** can be applied for 20 minutes, 3 times a day to help eliminate swelling and discomfort.
- **Compression** can be applied using an elastic bandage or another type of compressive stocking to further combat swelling.
- **Elevation** can be accomplished by supporting the leg so it is above the level of the heart. This helps decrease swelling in the affected area.

50% of the tendon, or are long standing, the degenerative segment may have to be removed completely. The remaining portion of the peroneus brevis tendon is then attached to the peroneus longus tendon in a procedure called tenodesis, which means "tendon binding."

Acute subluxation of the peroneal tendons is initially treated with rest, immobilization, and protected weight bearing. In high-level athletes, surgical intervention, including repair of the retinaculum that holds the tendons within the fibular groove behind the ankle, is often necessary. If the condition persists, the patient may require a more invasive procedure to keep the tendons in their proper place. In such cases, surgery can be done to deepen the fibular groove before repairing the retinaculum. Overall, with adequate time and rest, patients should recover fully from peroneal tendon injuries.

Preventing peroneal tendon injuries

To help prevent peroneal tendon injuries, those participating in sports that require repetitive ankle movements should be sure to include a regimen of stretching and strengthening of the lower leg muscles. Athletic shoes that offer adequate cushioning and support for the foot are also essential for avoiding peroneal tendon injuries. Furthermore, increases in training should be made gradually so that tendons and other structures can adapt to the added demands. As is the case with most other types of injuries, when it comes to peroneal tendon problems, prevention is always preferable to treatment and rehabilitation.

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Meniscus Tears

The knee is the largest and most complex joint in the body. Although it is built to withstand all kinds of stresses from everyday activities, such as walking and bending—or even from more strenuous activities such as running—injuries to the various structures of this joint can and do occur. A common type of knee injury is a tear of the meniscus, 1 of the fibrocartilage discs inside the joint. When you hear people say that they have torn the cartilage in their knee, they usually mean that they have torn their meniscus.

Knee anatomy

The knee joint consists of the lower end of the femur (thighbone) and the upper end of the tibia (shinbone), while a third bone, the patella (kneecap), slides in a groove at the end of the femur. Two main ligaments provide stability for side-to-side motion at the knee: the medial collateral ligament (MCL) and the lateral collateral ligament (LCL). Within the joint, 2 other ligaments can be found: the anterior cruciate ligament (ACL) and its counterpart, the posterior cruciate ligament (PCL). At the end of both the femur and the tibia is a thin layer of hyaline cartilage, a translucent bluish-white cartilage that is slippery and reduces friction. Additionally, between these 2 bones rest 2 crescent-shaped fibrocartilage discs called menisci (meniscus, the singular form, is from the ancient Greek word for "little or crescent moon") (Fig., pg. 5). The medial meniscus (inside disc) is C-shaped, while the lateral meniscus (outside disc) is more U-shaped.

Meniscus function

The menisci are tough and rubbery and serve as cushions between the bones of your knee joint. They also distribute your body's weight and absorb shock so that the weight load transfers from the femur to the tibia smoothly. In addition to stabilizing the knee, the menisci contribute to the lubrication and nourishment of the joint. A meniscus can be torn by a sudden twisting and turning motion, as occurs predominantly in younger individuals while playing sports. If you are an athlete who participates in contact sports, such as football, or activities that involve pivoting, such as tennis or basketball, you are at greater risk for a torn meniscus.

Each meniscus can be divided into 3 parts. The outer third or rim is vascular, which means it contains an abundance of blood vessels that transport blood to supply oxygen and nutrients to the area. The middle third is less vascular while the inner rim of the meniscus is completely avascular or lacking in blood vessels. Thus, whether or to what extent your meniscus tear heals depends greatly on its location—tears on the vascular part usually heal well while those on the avascular portion do not heal at all. Your injury can also be classified according to the way in which the tear extends into or from its meniscus. For example, when a fragment tears off the medial meniscus and extends into the joint

space, it resembles a bucket handle, and is therefore called a bucket-handle tear.

Symptoms

While you can tear your meniscus by twisting your knee or damage it by tearing your ACL, you can also tear your meniscus in a less forceful way, which means you may experience only gradual pain and swelling in the joint. A prominent symptom of a torn meniscus is a "clicking" sensation inside the joint with or without intermittent locking of the knee. Any type of meniscus tear will likely cause some pain and swelling. You may also have stiffness in the joint and be unable to bend it completely.

Diagnosis and imaging

In diagnosing knee injuries, x-rays are often used to rule out fractures and to detect the presence of any loose bodies within the joint. They are also used to estimate the amount of space inside the knee joint and to look for signs of arthritis; however, an x-ray will not show the menisci themselves. Using extremely high frequency sound waves, an ultrasound test can produce images of the inside of the knee joint as it moves. As a diagnostic tool, it can help to determine whether a loose flap of torn cartilage is getting caught in the joint as the knee bends and straightens. The best tool, however, for diagnosing a meniscus tear is magnetic resonance imaging (MRI)—a scan that uses radio waves and a strong magnetic field to produce cross-sectional images of internal structures, including soft tissues such as the menisci, tendons, and ligaments.

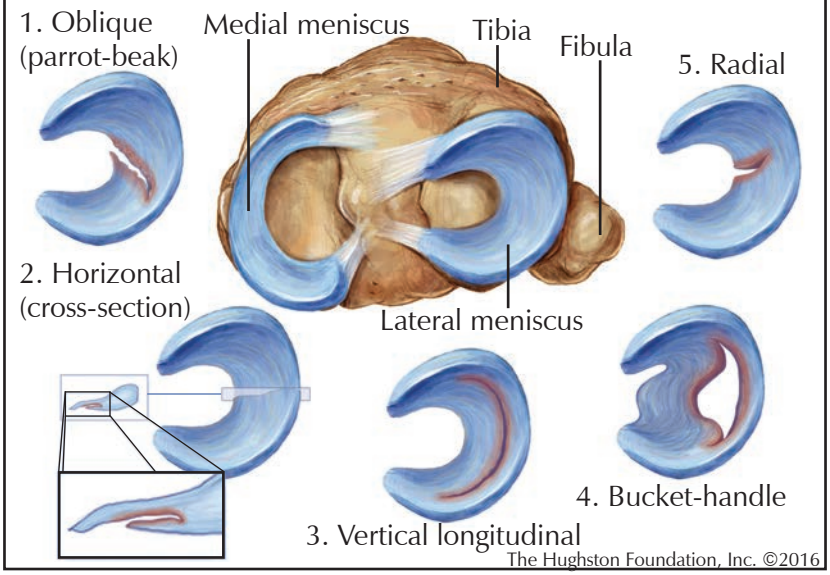

Fig. Normal right knee anatomy (aerial) & types of meniscus tears

Treatment

The treatment plan for your torn meniscus will depend largely upon the type and size of the tear as well as its location—whether in a vascular or avascular part of the fibrocartilage disc. Your age, health, and current activity level will also be factors in determining the best treatment options from management of symptoms to postsurgical therapy.

Management of symptoms. Whether or not you need surgery, there are measures you can take to manage the symptoms of a torn meniscus. Resting the knee, applying ice and compression (as with an ace bandage), and keeping the limb elevated are initial steps you can take to control the swelling and inflammation in your knee. Taking nonsteroidal anti-inflammatory drugs (NSAIDs) may also help to reduce inflammation and alleviate pain.

Nonsurgical treatment. If your symptoms do not subside, your doctor may recommend a corticosteroid injection into the area to decrease the inflammation. Additionally, you may benefit from wearing an athletic brace to support the injured knee. If your affected leg continues to be weaker than the other, you can try physical therapy to strengthen the muscles that support the knee. These are measures to consider when surgery is not applicable. For instance, tears in the vascular area (outside third) of the meniscus heal on their own while horizontal, flap, long-standing, and degenerative tears of the meniscus cannot usually be repaired by surgery.

Surgical treatment. Most meniscus tears occur in the avascular portion (inside third) of the disc, which means they do not heal; however, they can be removed during arthroscopic surgery by using a camera and shaver that are inserted through small incisions in the skin. Such a procedure is called a partial meniscectomy. It is typically performed in cases of displaced bucket-handle tears (where a fragment of the outer rim of the meniscus extends into the joint space resulting in locking and clicking of the knee joint) or in cases where there is also an ACL injury. Additionally, radial or vertical tears to the meniscus can often be repaired surgically. If surgery is needed, it should be done promptly to avoid further injury to the meniscus. However, if you have a tear in the vascular area that does not heal properly and later requires surgery, waiting should not affect the outcome.

Postsurgical therapy. After surgery, you may need physical therapy to gain strength and flexibility in the leg muscles, especially those surrounding the knee. A physical therapist can help you to establish strength, flexibility, and range of motion goals and to work toward them by monitoring your progress and any pain you may have.

Staying in the game

Regardless of its type or whether or not it requires surgery, a tear to the meniscus does not have to permanently sideline you from playing sports or doing the activities you love. Getting a prompt diagnosis and proceeding with treatment as soon as possible will speed your recovery and return to play.

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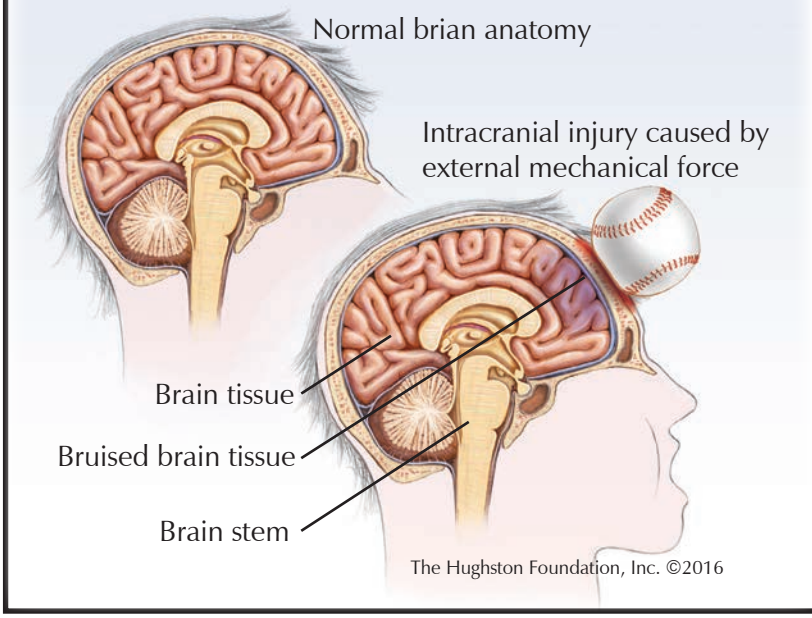
Traumatic Brain Injury

A head injury or traumatic brain injury (TBI) can happen to anyone. Every year between 1.5 and 4 million Americans suffer a TBI during recreation or while on the job. Due to training and combat, military personnel have a higher likelihood of incurring a TBI. The elderly are especially vulnerable to TBIs because of their propensity to fall. Not surprisingly, organized sports present some of the most common venues where you or someone you know could sustain traumatic injury to the brain. The Centers for Disease Control (CDC) reports that more than 173,000 children are treated during emergency room visits for sports-related TBIs each year. The highest rates of TBI occurrence are found in football and girls' soccer programs. Overall, TBI is a major cause of disability and death worldwide.

Fig. Anatomy & common causes of TBI



What is traumatic brain injury?

The brain is enclosed in the cranium (skull) where it is surrounded by cerebrospinal fluid—a clear, colorless fluid produced inside the ventricles (cavities) of the brain and meant to protect it from injury. Traumatic brain injury (TBI), sometimes referred to as intracranial injury, occurs when an external mechanical force causes injury to the brain (**Fig.**). The damage to the brain can then be either focal, meaning confined to 1 area, or diffuse, meaning it involves multiple areas of the brain. The injury can also be open or closed, depending on whether or not the skull is penetrated. Examples of closed TBI include impact due to violence, a vehicular accident, or a fall. An impact can cause the brain to strike the inside of the cranium and bruise, stretch, or tear brain and nerve tissue. Open TBI can happen when a blunt force or projectile penetrates the skull and damages the brain. By contrast, brain injuries that are not the result of external mechanical force are considered nontraumatic. They occur when problems with breathing, cardiac arrest, or bleeding cause the brain to receive too little or no oxygen —conditions known as hypoxia and anoxia, respectively— and brain cells die as a consequence. If you suffer a mild TBI, you may experience a temporary dysfunction of brain cells. Moderate to severe TBI can damage your brain and lead to paralysis or coma.

What are the symptoms of TBI?

TBI causes problems by interfering with the communication pathways in your brain. After suffering a TBI, you may experience physical symptoms such as headaches, nausea, vomiting, fatigue, lethargy, dizziness, lack of motor coordination, blurred vision, ringing in the ears, or aphasia (the inability to speak). If your head injury is more severe, you may also experience convulsions, seizures, numbness, or partial paralysis.

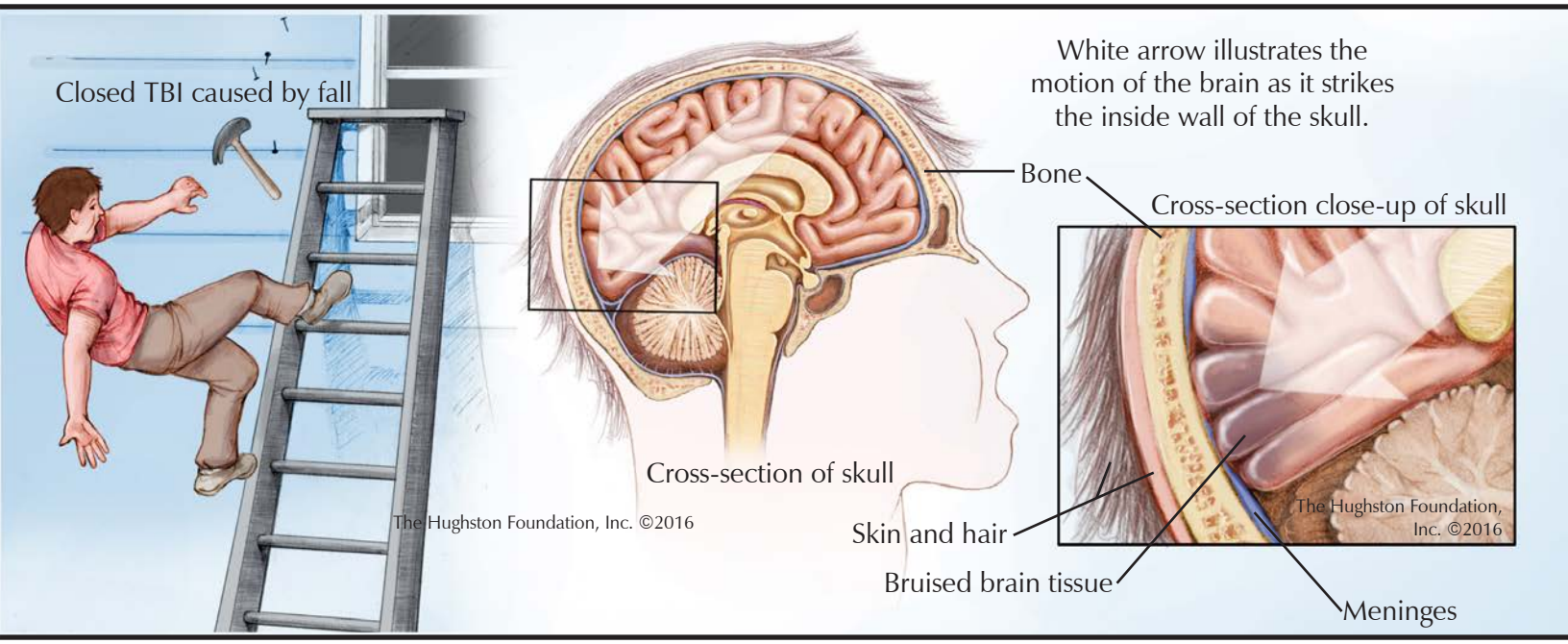
After sustaining a TBI, you can develop problems with memory and concentration or trouble sleeping, as well as emotional problems such as anxiety and irritability. As a rule, patients who have TBI have more problems with anxiety and posttraumatic stress disorder (PTSD)—a mental health condition triggered by experiencing a traumatic event—than the general population. Not only are many of the symptoms of PTSD similar to those of TBI, but the 2 conditions often coexist because brain injuries are frequently sustained during traumatic experiences.

The most common problem you are likely to face after a TBI is cognitive dysfunction or interference with thinking skills. This usually manifests as difficulty focusing: you forget appointments or where you left items such as keys and purses; you are unable to remember conversations, do simple tasks, or study. Cognitive problems can be extremely frustrating and may increase your anxiety, but over time, your symptoms will generally improve as your brain develops new pathways, allowing it to return to normal.

How is TBI diagnosed?

If you suffer a trauma to your head or neck, x-rays can be performed in an emergency room to check for bone fractures or spinal instability. Your doctor may diagnose TBI by having you undergo a computed tomography (CT) scan. The scan creates a series of cross-sectional x-ray images of the brain and cranium. A CT scan can show bone fractures as well as the presence of hemorrhage (bleeding), hematomas (blood clots), contusions (bruises), and brain tissue damage. Magnetic resonance imaging (MRI), which can produce high-resolution images of brain structures, is also a useful diagnostic tool, but is more costly.

If you suffer a TBI, it will be labeled mild, moderate, or severe, depending on your symptoms and according to the Glasgow Coma Scale (GCS). The GCS is a clinical tool used to evaluate your level of consciousness and degree of neurological functioning—and therefore the severity of your brain injury—on a scale of 0 to 15 based on motor,



verbal, and eye-opening responses. A mild case (13 to 15 on the GCS) of TBI is diagnosed as a concussion, and the most severe cases (a score of 1 to 3) involve coma.

How is TBI treated?

After any kind of TBI, even a mild concussion, the most important thing is to prevent another head injury from happening during your recovery period. Depending on the severity of your present injury, your doctor may recommend taking time off from sports. Moreover, as a TBI patient, you may be assigned a nurse or case manager who can assist you in making appointments with specialists. Your treatment plan may not only involve multiple specialties, but also ongoing assessments to evaluate and redirect treatment. For example, since headaches are extremely common with TBI, you may be referred to a headache specialist for treatment. A psychologist or neurologist can test you to evaluate your memory and attention span, and a speech therapist can treat you for issues with communication. If you have balance problems or dizziness, you should undergo physical therapy. You may also want to have sleep testing, especially if sleep apnea (when breathing stops and starts during sleep) is an issue.

What are the possible long-term effects of TBI?

If you sustain a mild TBI, you have an excellent chance for a complete recovery. Although most mild cases do resolve within 3 weeks, a repeat head trauma within 1 to 2 weeks can lead to chronic problems. Approximately 125,000 TBI sufferers experience ongoing problems, and 50,000 die each year from the effects of brain injury. Moreover, the prognosis worsens with the severity of the injury: while permanent disability is found in only 10% of mild cases of TBI, this number increases to 66% with moderate cases and to nearly100% with severe cases. Additionally, where the brain has been injured makes a difference, especially with the presence of a hematoma or damaged blood vessels. For example, the occurrence of a subarachnoid hemorrhage—bleeding between the middle and inner most of the 3 meninges (membrane coverings) of the brain—doubles the mortality rate, and a subdural hematoma—a blood clot between the outermost and middle meninges—means a worse outlook and increased mortality rate for the patient compared to an epidural hematoma—blood clot above the outermost of the meninges. The outlook is good for the latter case if surgery is performed quickly. Coma results from severe and diffuse trauma to the brain and is a strong predictor of poor outcome. When patients die from TBI, it is usually due to secondary injury. A secondary injury can involve swelling of the brain which causes chemicals that promote inflammation to be released. As there are no adjacent tissues to absorb the excess fluid and there is limited space to expand within the skull, the intracranial pressure increases and can cause brain damage to occur. This can lead to respiratory failure and death. Preventing this scenario is the focus of acute medical care during "the golden hour" following a head injury.

What is the general outlook for TBI sufferers?

With any TBI, it is important to seek treatment immediately, avoid further injury, and rest. No 2 brain injuries are exactly alike—the effects of TBI are complex and vary greatly from 1 individual to another. Your unique set of challenges as a TBI sufferer could put stress not only on you, but also on your family members, so it is important to seek out the help and support you need. Today the outlook for TBI sufferers is better than ever. Although the road may be long, with effort and patience, you can make considerable progress toward recovering from TBI.

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