ABSTRACT: Fractures of the stifle are not uncommon in horses and can often be life threatening or career ending if not treated appropriately. These injuries can be treated successfully, particularly in foals. Body size, future intended use, and the osseous structures involved will affect therapeutic options and prognosis for future soundness.

Because of the size, range of motion, and complexity of the equine stifle joint, fractures and osseous injuries of this joint can be challenging to manage. Simultaneous articular soft tissue or ligament injuries can make diagnosis, treatment, and rehabilitation more challenging. Prompt diagnosis, proper case selection, and optimal surgical management are necessary to restore joint stability and function. This article describes the diagnosis, treatment, and prognosis of the most common and clinically relevant fractures and osseous injuries of the stifle in horses.

PATELLAR FRACTURES

Patellar fractures are rare in horses and are often the direct result of impact trauma such as a kick or colliding with a stationary object. They can occur in horses that strike a fence or cross rail with the stifle while jumping at high speeds. The stifle is fully flexed and the patella is fixed in the trochlear groove while jumping, concentrating the force of the impact on the patella.

Patellar fractures may be articular or nonarticular. The fracture configuration can be sagittal (longitudinal), transverse (horizontal), comminuted, or an avulsion fracture at an attachment of a patellar ligament. Sagittal patellar fractures occur more commonly on the medial side after impacting the patella on the large medial trochlear ridge of the femur (Figure 1). Transverse patellar fractures are often midbody or involve the distal third of the patella and are usually markedly distracted due to the pull of the quadriceps muscle group on

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Figure 1—Dorsoproximal to dorsodistal (skyline) radiographic view of the stifle of a horse with a nondisplaced sagittal fracture of the patella. The fracture line is located axially on the patella.

Figure 2—Dorsoproximal to dorsodistal (skyline) radiographic view of the stifle of a horse with a minimally displaced, axial sagittal fracture of the patella. (Courtesy of D.R. Richardson, DVM; University of Pennsylvania.)

the proximal fragment. Comminuted fractures can occur in any configuration. Avulsion fractures of the patella can occur at the attachments of the patellar ligaments and may be due to a sudden, forceful contraction of the quadriceps muscle group during strenuous activity or a fall. Fragmentation of the distal aspect of the patella has been reported with increased frequency in horses when a medial patellar ligament desmotomy is combined with early postoperative exercise.

Clinical Signs and Diagnosis

Horses with large patellar fractures usually present with an acute onset of severe lameness following a traumatic event. Marked periarticular soft tissue swelling and crepitation usually accompany these fractures. Femoropatellar effusion is prominent in cases with a significant articular component, and affected horses will usually toe-touch the limb to the ground when weight-bearing during walking or standing. Horses with patellar avulsion fractures or fragmentation of the patellar apex are often presented with less synovial effusion and soft tissue swelling over the patella. The lameness is usually less severe than in horses with other configurations of patellar fractures.

Limb manipulation tests and intraarticular anesthesia are usually not necessary when evaluating horses with transverse, sagittal, or comminuted patellar fractures because the marked soft tissue swelling, synovial effusion, and degree of lameness will readily localize the source of lameness to the stifle. It may be necessary to perform these procedures in horses with small intraarticular fragmentation or avulsions of the medial aspect of the patella to localize the source of the lameness.

Radiographs of the stifle that image the entire patella are necessary for accurate diagnosis, preoperative planning, and determining prognosis. The lateromedial, flexed lateromedial, and caudocranial projections are usually adequate for evaluating transverse patellar fractures. The caudolateral to craniodorsal and cranomedial to cranioventral oblique views are adequate for evaluating the distal border of the patella in cases of patellar fragmentation or avulsion fractures. The dorsoproximal to dorsodistal (skyline) patellar projection is necessary to image sagittal patellar fractures and avulsion fractures on the medial aspect of the patella (Figures 1 and 2). The skyline view may be difficult to obtain in standing horses with sagittal, transverse, or comminuted patellar fractures because the animals often resent having their stifle fully flexed to obtain the radiograph. Sedation with IV detomidine (0.05 to 0.1 mg/kg) and IV butorphanol (0.05 to 0.1 mg/kg) or general anesthesia may be necessary to adequately and safely obtain this projection.

Ultrasonography can provide additional information on the integrity of the patellar or trochlear ridge articular cartilage, synovial membrane, fibrous joint capsule, patellar ligaments, collateral ligaments, menisci, and cruciate ligaments. Nuclear scintigraphy may identify an area of increased bone metabolic activity in the patella that may not be evident radiographically. An area of increased radiopharmaceutical uptake would be indicative of osteitis of the patella due to patellar ligament disruption, sepsis, or
blunt trauma that may occur in lieu of a detectable radiographic lesion.\(^7\)

**Treatment and Prognosis**

Patellar fractures are often treated surgically to restore the congruency of the articular surface and reestablish the function of the quadriceps mechanism. Conservative treatment of patellar fractures with marked disruption of the quadriceps mechanism and articular surface is generally unrewarding and offers little hope for restoring an athletic career.\(^2\)\(^-\)\(^4\)\(^,\)\(^3\)\(^-\)\(^4\) Severe degenerative joint disease (DJD) usually ensues preventing even a sedentary, pain-free life.\(^5\) Internal fixation is indicated when there is a disruption of the quadriceps apparatus.\(^1\)\(^-\)\(^4\),\(^3\)\(^-\)\(^4\) Nondisplaced sagittal fractures may heal with a fibrous union after 60 to 90 days of stall rest.\(^4\)\(^,\)\(^8\) Serial radiographic monitoring for displacement during conservative management of nondisplaced sagittal patellar fractures is recommended.\(^4\)\(^,\)\(^8\) If healing occurs with a fibrous union, the fracture line will often be a persistent radiographic finding even in sound horses. Therefore, the amount of synovial effusion and severity of clinical lameness are more important when evaluating healing or suitability for increasing activity levels.\(^4\) Surgical intervention for a patellar fracture is indicated if any of the following are present: (1) a fracture line is palpable through the fascia dorsally over the patella; (2) a radiographic fracture gap greater than 5 mm, indicating that the fracture is displaced with significant articular surface disruption; (3) an incongruent articular surface; or (4) a transverse or comminuted fracture in which the pull of the quadriceps muscle group distracts the fracture fragments or disables the quadriceps mechanism\(^5\) (Figure 2).

Full limb casts or splints should not be used to treat patellar fractures because they increase the distractive force of the quadriceps muscle group on the fracture.\(^4\) Lag screw internal fixation of transverse and sagittal patellar fractures is recommended.\(^1\)\(^-\)\(^4\),\(^11\)\(^-\)\(^13\) The location of the surgical approach depends on the configuration and location of the fracture.\(^4\) For reduction and internal fixation of transverse or sagittal patellar fractures, a curvilinear incision (starting proximally over the medial or lateral aspect of the patella) is carried deeply through the peripatellar fascia, patellar ligament, and quadriceps muscles to create a medial or lateral arthrotomy to permit reduction of the fracture, placement of the implant(s), and inspection of the articular surface for congruency.

Arthroscopy of the femoropatellar joint can be a useful adjunct to surgical therapy to assess the degree of articular damage before fixation and to evaluate fracture reduction and alignment after surgical repair. Disruption of the peripatellar tissues should be kept to a minimum by maintaining a single plane of dissection. Disruption of the soft tissues may make secure closure of the incision difficult and more prone to dehiscence.\(^2\)\(^-\)\(^4\),\(^12\),\(^13\) Repair with 5.5-mm cortical screws is preferable to 4.5-mm cortical screws when the size of the patellar fragments and the horse permit their use. The 5.5-mm cortical screw is more resistant to cyclic failure, generates more compression, and is more resistant to pullout when compared with 4.5-mm cortical screws placed in cortical bone.\(^4\)\(^,\)\(^14\),\(^15\) This is particularly important when managing transverse patellar fractures because the pull of the quadriceps apparatus on the fracture repair is considerable. The use of 6.5-mm cancellous screws in patellar fracture repairs has also been reported.\(^2\) Tension band wiring of the cranial aspect of the patella using 16- or 18-gauge orthopedic wire may be necessary to reinforce lag screw fixation of transverse fractures to help neutralize the pull of the quadriceps mechanism on the fracture repair.\(^5\)\(^,\)\(^11\),\(^12\)\(^,\)\(^16\) Comminuted fractures can be repaired using lag screw fixation and tension band wiring of the largest fragments and removal of the smaller pieces.\(^1\)\(^-\)\(^3\),\(^\_\)\(^11\)

Partial patellectomy is indicated for removal of intraarticular fragments that are too small for internal fixation. Larger sagittal fragments from the distomedial or axial border of the patella are best removed surgically. They have a tendency to displace when treated conservatively and are usually articular.\(^9\) Removal of up to a third of the patella in horses has resulted in a successful outcome.\(^9\) Medial patellar fractures or small sagittal fractures can be removed by a surgical approach centered over the fragment medially.\(^9\) Arthroscopically guided removal of intraarticular fragments is preferable to liberal arthrotomy incisions. The arthroscope is placed laterally between the middle and lateral patellar ligaments to enhance visualization of the distomedial aspect of the patella where most fragmentation occurs.\(^5\)\(^,\)\(^7\) Placement of the arthroscope and instrument portals in the suprapatellar pouch is best suited for removal of osteochondral fragments originating from the proximal aspect of the patella (Figure 3). The fragments are localized and dissected free using arthroscopic guidance via a distolateral or distomedial instrument portal. Smaller fragments are removed through the instrument portal, and larger fragments can then be removed by performing a limited arthrotomy directly over the fragment.\(^5\)\(^,\)\(^7\)

Liberal arthrotomy incisions of the femoropatellar joint to localize and retrieve these fragments are predisposed to incisional complications.\(^4\)\(^,\)\(^9\) Dehiscence can occur because of suture line tension from soft tissue swelling, stifle flexion, and femoropatellar joint effusion. Arthrotomy approaches centered medially
may disrupt all or parts of the attachments of the sartorius and gracilis muscles, the origin of the medial patellar and femoropatellar ligaments, and the tendon of insertion of the vastus medialis. Small nonarticular avulsion fragments on the axial aspect of the patella usually do not require surgical intervention because they often lack an articular component. If the location of the avulsion fragment is in doubt, the joint should be explored arthroscopically.

TIBIAL TUBEROSITY FRACTURES

Tibial tuberosity fractures are rare in horses and are usually the result of blunt trauma to the cranial aspect of the proximal tibia. There is little soft tissue protection for the prominent cranial bony protuberance of the tibial tuberosity, and this may concentrate disruptive forces onto this bony prominence. The tibial tuberosity has a separate physis. In horses, it is partially ossified at birth and will fuse with the proximal tibial epiphysis at 2 to 3 years of age. The quadriceps mechanism attaches to the tibial tuberosity through the middle patellar ligament, and this may increase the magnitude of the disruptive forces transmitted to the bone during forceful contraction or maximal loading of the quadriceps. These fractures may be articular depending on the depth of the fracture line and the caudal angle of propagation relative to the cranial cortex of the tibia.

Clinical Signs and Diagnosis

There is an acute onset of severe lameness on the affected limb with swelling and crepitus on the proximal cranial aspect of the tibia. These clinical signs are more pronounced if the fracture is displaced. Large fractures with an articular component will present with marked effusion of the femoropatellar joint. The effusion may be difficult to appreciate if the periarticular swelling is severe during the acute stages of the injury.
Lateromedial radiographic views of the stifle and proximal tibia are usually diagnostic for displaced tibial tuberosity fractures17,18 (Figure 4). It may be necessary to radiograph the opposite tibia in young horses because nondisplaced fractures may appear radiographically similar to the active tibial tuberosity physis present in horses up to 36 to 42 months of age.17 It is important to obtain a complete set of quality radiographs that will image any articular extension of the fracture line as well as concurrent injuries to the patella or distal femur. Horses with an articular component to the fracture may have a concurrent injury to the body or attachment of the cranial cruciate ligament or the intercondylar eminence of the tibia. These injuries increase the opportunity for development of DJD and worsen the prognosis for soundness.17 Horses with nondisplaced fractures that have a normal radiographic appearance should be further evaluated with nuclear scintigraphy to determine if a pattern of radiopharmaceutical uptake consistent with a stress fracture is present. The scintigraphic study should be performed 3 to 5 days after the injury to allow the increase in bone metabolism consistent with a fracture or injured bone to be evident.19

If concurrent soft tissue injuries to the stifle are suspected, the joint can be evaluated ultrasonographically. Injuries to the patellar or collateral ligaments or the cranial border of the menisci can often be assessed ultrasonographically.10

**Figure 4**—Lateromedial radiographic view of the stifle in a horse with a tibial tuberosity fracture. (From Smith BL, Auer JA, Watkins JP: Surgical repair of tibial tuberosity avulsion fractures in four horses. *Vet Surg* 19(2):117–121, 1990; with permission.)

**Treatment and Prognosis**

Nondisplaced tibial tuberosity fractures may heal with conservative treatment after a convalescence of 3 to 6 months.8 The fracture should be evaluated radiographically at 7- to 10-day intervals during the initial 6 to 8 weeks to identify any displacement that may occur from the pull of the quadriceps mechanism on the tibial tuberosity through the middle patellar ligament.8 Cross-tying the patient to prevent recumbency may be necessary for the first 4 to 6 weeks to prevent fracture displacement while attempting to stand.8 Internal fixation may be superior to conservative therapy when treating nondisplaced tibial tuberosity fractures by counteracting some of the distraction forces of the quadriceps mechanism that can interfere with bone healing, thereby shortening the convalescent period.

Internal fixation is indicated for all displaced tibial tuberosity fractures and those with an articular extension of the fracture line.8,17,18 Displaced fractures disable the cranial insertion of the quadriceps mechanism to the tibia, markedly compromising stifle support and function. Horses with an articular component to the fracture must be treated surgically in an attempt to reestablish the congruency of the articular surface and attachments of the articular soft tissues to prevent DJD and joint instability.17,18 The fracture is stabilized using the tension band principle by incorporating 5.5-mm cortical screws in lag fashion through a 4.5-mm dynamic compression plate (DCP).17 A 4.5-mm broad DCP should be used whenever fragment size permits. By avoiding screw placement in the same sagittal plane as occurs with a narrow compression plate, the staggered screw holes of the broad plate reduce the probability of creating longitudinal fissures through the tibial tuberosity.17

Lag screws (4.5- or 5.5-mm cortical) and tension band wires (16 or 18 gauge) may be used in nonarticular tibial tuberosity fractures that are smaller and where plate application is limited due to fragment size18 (Figure 5). Small, nondisplaced fragments that are not amenable to internal fixation may be left in place if not displaced.8 Small, displaced fragments can be removed surgically by atraumatic dissection under the insertion of the middle patellar ligament.18

Horses with displaced tibial tuberosity fractures that can be adequately stabilized with the implants remaining secure during the anesthetic recovery and postoperative period have a good prognosis for full return to function.17,18 In four horses with displaced tibial tuberosity fractures treated surgically, two were euthanized because of implant failure or fracture through the tibial tuberosity fragment during the...
anesthetic recovery or immediate convalescent period. The other two horses survived without complications and became riding sound.17 Injury to the cranial cruciate ligament or intercondylar eminence of the tibia associated with an articular fracture may worsen the prognosis for the integrity of the repair and long-term soundness.17,18 Small or nondisplaced tibial tuberosity fractures that are treated conservatively have a good prognosis for full recovery after a long convalescent period if the fragment(s) does not displace due to the constant pull of the quadriceps.8 Horses with smaller displaced fragments that are removed surgically with minimal disruption of the middle patellar ligament usually recover completely.18 Early recognition and proper case management of tibial tuberosity fractures improve the prognosis for full return to function. In selected cases, conservative management may be an option, but close monitoring of each case is necessary to manage complications appropriately.

**DISTAL FEMORAL FRACTURES**

Distal femoral diaphyseal or metaphyseal fractures in adult horses are not common and are often comminuted.4 The smaller distal metaphyseal fragment(s) are often inadequately sized to permit secure placement of an internal fixation device that can effectively withstand the stresses placed on it due to the increased body weight. Conservative management of displaced distal femoral fractures in adults with confinement alone would likely result in flexural contracture, contralateral limb breakdown, and prolonged patient discomfort. Nondisplaced, incomplete Salter-Harris distal femoral physeal fractures (Figure 6) can be managed conservatively with stall rest. Frequent radiographic monitoring should be performed to evaluate fracture healing. External coaptation is contraindicated with this type of fracture because it would increase the lever arm effect across the fracture line.

An adult horse with a femoral condylar fracture involving 25% of the caudal aspect of the condyle was successfully returned to function by removing the condylar fragment through a caudal arthrotomy centered over the fragment.20 Femoral fractures are common in foals21 and are the result of trauma from a blow or a fall. Many fractures are diaphyseal or have a large diaphyseal component because the femur is a relatively short bone in foals.4,22 Distal femoral fractures in foals are most commonly Salter-Harris type II23 with a variably sized metaphyseal fragment.22 Salter-Harris type III and IV distal femoral fractures have also been reported in foals.22

**Clinical Signs and Diagnosis**

Affected foals have an acute onset of non–weight-bearing lameness with a variable degree of soft tissue swelling over the stifle depending on the duration, displacement, and location of the fracture. Foals with nondisplaced distal diaphyseal femoral fractures may be very lame on presentation but with minimal soft tissue swelling over the stifle.22 Due to contracture of the
thigh musculature and the quadriceps mechanism, the fracture ends may have significant overriding so that the affected leg appears shorter than the opposite limb.

Crepitus of the stifle region is usually obvious when the joint is manipulated. Marked soft tissue swelling of the stifle region can also occur in foals with synovial sepsis of the stifle or a traumatically induced hematoma. A foal with a hematoma of the stifle is usually not as lame as a foal with a fracture of the distal femur, and there is no crepitation present unless there is a break in the skin with air accumulation in the soft tissues. Stifle radiographs are usually normal, and ultrasonographic examination and fluid analysis of the soft tissue swelling should confirm the presence of recent hemorrhage. A large hematoma or seroma may need to be drained after the hemorrhage ceases to minimize compromise to the vascular supply of the skin.

Foals with synovial sepsis of the stifle are usually markedly lame with or without crepitus of the stifle during manipulation. They are presented with moderate periarticular swelling, and stifle radiographs can be normal early in the disease process. In foals less than 5 months of age, the proximal edges of the trochlear ridges are radiographically irregular and the subchondral bone has variable radiographic density. These findings should not be misinterpreted as a septic process with bony lysis when evaluating stifle radiographs in young foals. Synovial fluid analysis can be a valuable diagnostic tool to characterize the nature of the synovial effusion and severity of synovitis. Normal synovial fluid in horses has less than 2.5 g/dl of protein and total leukocyte counts less than 1000 cells/µl. Synovial fluid samples from septic joints will usually have total leukocyte counts greater than 30,000 cells/µl consisting of mostly (greater than 90%) mature neutrophils and synovial fluid protein levels that usually exceed 4.0 g/dl. When mature neutrophil counts in synovial fluid exceed 100,000 cells/µl, the joint should always be considered septic. Gram stains or cytologic evaluation of the fluid and bacterial cultures may identify the infective bacteria. Therapy for these foals consists of identifying and treating or eliminating the source of the infection (e.g., penetrating wound, infected umbilical remnants, hematogenous seeding), immunoglobulin administration for cases with failure of passive transfer, appropriate systemic antimicrobial therapy, and synovial lavage and drainage to reduce the infective load and remove fibrin accumulation.

Standard lateromedial, caudocranial, and oblique radiographic views are diagnostic for distal femoral fractures. Foals with distal femoral fractures have variable amounts of fragment displacement, depending on the configuration of the fracture. Marked cranial, caudal, medial, or lateral overriding of the fracture fragments can occur due to contraction of the musculature of the thigh when the femoral strut is compromised. Distal femoral physeal fractures are most commonly Salter-Harris type II with a large cranial or caudal metaphyseal fragment. Salter-Harris type IV fractures that run parallel to the tibial plateau, through the trochlear ridges and distal femoral physis, and exit at the caudal femoral metaphysis have also been reported. Coaptation of these fractures as a first-aid measure is contraindicated because any full limb splint applied proximally to the distal level of the stifle will increase the lever arm effect of the distal limb across the fracture line, further disrupting the soft tissues and fracture ends. The extensive musculature of the stifle will function as an internal splint, and most foals can ambulate on three legs readily, thereby protecting the fracture until surgery is performed.
using 4.5- or 5.5-mm cortical screws in a laterally placed 5.4-mm dynamic condylar screw (DCS) plate, 5.6-mm angle blade plate, 4.5-mm broad DCP, or a 6.0-mm cobra head plate (Figure 8) is recommended to increase purchase in the epiphyseal fragment of the distal femur.

A lateral approach to the femoral diaphysis is used to expose the femur, to clean and evacuate the fracture line, and for implant placement. Exposure to the distal femoral epiphysis can be accomplished by partially incising the attachment of the biceps femoris to the lateral patellar ligament. This distal exposure allows placement of the lateral plate on the femoral epiphysis and permits reduction of the physeal fracture. Reducing Salter-Harris type II fractures with a large caudal metaphyseal spike can be difficult due to contraction of the thigh musculature and the amount of fracture fragment overriding often present at surgery.

The pullout strength of 5.5-mm cortical screws in foal bone is greater than that of 4.5-mm cortical screws.
Therefore, 5.5-mm cortical screws should be used whenever possible in repairing femoral fractures in foals to increase the strength of the repair. The DCS plate requires special instrumentation that is specific for the DCS system to place the condylar screw portion of the implant in the distal femoral epiphysis. The balance of the 5.5-mm cortical screws can be placed through the plate into the bone using standard Association for the Study of Internal Fixation instruments. All screw holes in the plate should be filled and the lag screw technique should be used whenever possible to increase interfragmentary compression. Fractures with a large metaphyseal fragment or a more proximal diaphyseal component can be repaired with two plates. The second plate should be a standard 4.5-mm broad DCP applied to the cranial surface of the femur as a neutralization or compression plate.

Seroma formation is the most frequent postoperative complication of femoral fracture repair in foals. Seromas compromise the integrity and vascular supply of the deep soft tissues and skin covering the metal implants. Compromise of the soft tissues and neurovascular structures can provide a favorable environment for sepsis of the surgical site to develop, which can lead to implant loosening and failure of the fracture repair. Meticulous soft tissue apposition, judicious use of closed suction drains, antibiotic coverage while the drain is in place, and close clinical monitoring of the surgical site are important to prevent sepsis. Implants may loosen during the healing of diaphyseal or distal physeal femoral fractures due to cycling during healing.

Because of the considerable soft tissue coverage and vascularity of the femur, diaphyseal femoral fractures in foals have a tremendous capacity to form callus and will quickly increase the strength of repairs that are not completely rigid after implant placement or those in which minor implant loosening occurs during healing. Distal femoral fractures are less tolerant of initial or ensuing implant instability due to their location at the end of the femoral strut. They do not form callus as readily. Small inconsistencies in fracture rigidity and position can result in delayed healing, implant failure, or articular malalignment.

Conservative management of nondisplaced or minimally displaced distal femoral fractures in young foals may result in satisfactory healing. However, development of tendon or articular contracture in the affected limb and angular limb deformity or tendon laxity in the contralateral limb are likely. These orthopedic disorders can develop rapidly in large young foals that are forced to ambulate on three legs.

The prognosis for foals with distal femoral physeal fractures is guarded. Because of the limited amount of bone available for secure implant purchase on the distal fragment, implant failure or loosening is not uncommon. Predisposition to seroma formation with sepsis and implant failure can complicate the clinical management of these cases.

**PROXIMAL TIBIAL FRACTURES**

Proximal tibial fractures that directly affect the stability and function of the stifle joint occur more frequently in foals than adult horses. The most common proximal tibial fracture configuration in foals is a Salter-Harris type II with the metaphyseal spike attached to the lateral side of the epiphysis (Figure 9). They are probably the result of a kick to the lateral aspect of the stifle while the foal is weight-bearing or they occur when the animal is attempting to stand with its leg caught under an immovable object.

**Clinical Signs and Diagnosis**

Proximal tibial Salter-Harris type II fractures in foals...
initiate on the medial aspect of the physis and propagate laterally, eventually entering the metaphysis and breaking out through the lateral cortex (Figure 9).

There is a sudden onset of severe lameness with marked swelling and instability of the stifle. Because the sharp metaphyseal spike is located laterally where soft tissue coverage is maximal, the soft tissues covering the fracture are usually intact. Older or heavier foals will usually grind the tibial metaphysis against the germinal layer of the physis during attempts to ambulate, causing permanent damage to the physeal cartilage. This may lead to complete premature physeal closure or discrepancies in physeal growth despite a successful repair.27 Neonates and young foals retain more of the physeal growth potential after these injuries because they do not traumatize the germinal chondrocyte layer of the physis as severely as older and heavier foals.28

Foals with sudden onset of severe lameness and stifle swelling should be evaluated radiographically with a minimum of lateromedial and caudocranial views that incorporate the proximal tibia, distal femur, and patella. There is usually minimal or no displacement of the major fragments on the lateromedial view but marked displacement and overriding on the caudocranial view (Figure 9). The lateral metaphyseal spike is variably sized with overriding often present laterally.18,28

Applying a splint or cast as a first-aid measure is not recommended. Attempts to splint or externally coaptate these fractures is not effective in limiting motion at the fracture because the lever arm effect across the fracture (physis) is enhanced by the added weight and stiffness of the distal cast or splint, increasing the degree of physeal trauma. All efforts should be directed toward an immediate reduction in the activity of the foal to minimize efforts at weight-bearing by the patient. Expedient diagnosis and early surgical intervention will protect the physis from further trauma.

**Treatment and Prognosis**

Internal fixation is recommended for all proximal physeal Salter-Harris type II fractures of the tibia. Conservative therapy is not an acceptable alternative because these fractures are displaced in a medial to lateral plane with marked overriding of the fragments.18,28 Any therapy short of anatomic reconstruction and rigid fixation results in unacceptable healing with irreversible growth plate trauma, a shortened leg, and compromised stifle function. Severe angular limb deformity and flexural contraction are predictable sequelae of conservative therapy. Attempts to manage these fractures with a cast or splint are equally unrewarding because the stifle joint cannot be immobilized effectively with external coaptation, thereby increasing the lever arm effect of the distal limb on the fracture line.

Cross pinning of proximal tibial Salter-Harris type II fractures is best suited for neonates up to 2 to 3 weeks of age (approximately 30 to 60 kg).28 Neonates that have soft cortical bone and orthopedic implants secured in this soft tissue have a higher incidence of failure than those implanted in older foals and adults.28,29 Cross pinning these fractures with two or three pins placed in divergent fashion through the epiphysis, physis, and into the metaphysis will provide proper alignment of the bone and some protection against rotational forces. Separate approaches to the medial and lateral aspect of the proximal tibia are required to provide adequate exposure for fracture reduction and pin placement. The fracture is reduced using a medial incision over the fracture. A 1/8- or 5/32-inch Steinmann pin is then driven into the tibial epiphysis cranial to the medial collateral ligament. The pin is driven distally across the physis and into the lateral tibial metaphysis, making sure the pin is seated in the far cortex distal to the lateral metaphyseal fracture line. Through a separate lateral approach, a pin of the same size is placed into the epiphysis caudal to the long digital extensor muscle and advanced distally through the physis and distal metaphysis to complete the cross pinning procedure.28 The repair can be reinforced by applying a 5.5-mm cortical or 6.5-mm cancellous lag screw into the lateral metaphyseal spike from the medial side or placement of a third pin from the cranial aspect of the tibia through the tibial tuberosity into the caudal metaphyseal cortex.28

If the fracture cannot be reduced from the initial medial approach prior to pin placement, then plate fixation should be used. Cross pin fixation eliminates the compressive effects of other forms of internal fixation across the physis, preserving any remaining physeal growth potential. However, the small diameter, smooth contour, and minimal compressive effects of the cross pins make this repair inherently weak with only marginal strength in larger foals.29 Cross pinning proximal physeal tibial fractures can be used successfully in neonates because of their quick healing and light body weight. Healing usually progresses rapidly and most repairs are rigid in 4 to 6 weeks at which time the implants can be removed.28 The pins and screws should also be removed, particularly if they become loose. Loose orthopedic implants are prone to sepsis, cause pain, and can migrate into the surrounding soft tissues. Pins left in place longer contribute little to support the healing fracture and become incorporated in the bone as the foal grows, potentially interfering with physeal growth.28
Paired 6.5-mm cancellous screws placed in lag fashion to secure the epiphysis to the intact medial metaphysis can also be used in foals to repair a Salter-Harris type II proximal tibial fracture. The 6.5-mm cancellous screws may provide increased holding power when used in neonatal epiphyseal and metaphyseal bone.\textsuperscript{4,15} Use of cancellous lag screws alone should be reserved for foals that weigh less than 60 to 70 kg and those in which the fracture can be completely reduced axially. The screws should be removed once the healed fracture is rigid (4 to 6 weeks) to avoid growth disturbances.

The recommended technique for repair of Salter Harris type II proximal tibial fractures in foals is placement of a medial plate(s) spanning the fracture line.\textsuperscript{29} In most foals, particularly those older than 1 month of age or that weigh over 60 kg,\textsuperscript{18,29} the compressive and torsional forces generated across the fracture cannot be adequately neutralized by cross pinning or lag screws alone. Because of the limited soft tissue coverage, a medial approach allows easy access to the fracture for reduction and implant placement when compared with a lateral approach. However, the limited soft tissue available to cover the implant(s) on the proximal medial aspect of the tibia can be a disadvantage and incisional problems are likely with poor surgical techniques. Fracture reduction can be difficult because the fracture ends of the physis may have been ground smooth leaving little bony interdigitation between the physis and metaphysis.\textsuperscript{29} Reducing these fractures can be accomplished by securing the plate medially in the metaphysis first and then placing and tightening the epiphyseal screws.\textsuperscript{29} Complete reduction of the fracture may not be obtained in older foals, in repairs for which surgery was delayed and for fractures with minimal fragment interdigitation. In these cases, applying the medial plate with less than perfect axial reduction will stabilize the fracture with the leg in a valgus angular limb deviation centered over the fracture line (physis). Since physeal growth on the lateral aspect of the physis is usually preserved with this type of fixation, the medial plate acts as a transphyseal bridge and as the fracture heals it helps correct the angular deviation.\textsuperscript{29} Removal of the plate in 4 to 8 weeks will depend on fracture healing, age of the foal, and degree of angular limb deviation still present.

A T-plate can be used in foals weighing less than 200 kg.\textsuperscript{18,29} The vertical arm of the T-plate is contoured to the medial tibial metaphysis and secured distally with 5.5-mm cortical or 6.5-mm cancellous screws. The horizontal portion of the T-plate is placed over the medial epiphysis and two 5.5-mm cortical or 6.5-mm cancellous screws are placed into the tibial epiphysis, parallel to the joint surface. As the screws are tightened, the epiphysis is drawn into anatomic reduction. The rest of the plate holes are filled in with 5.5-mm cortical or 6.5-mm cancellous screws, using the lag screw technique through the plate for the screws incorporated into the lateral metaphyseal spike.\textsuperscript{18,29} One or two lag screws can be used in most fracture repairs; however, in some foals the metaphyseal spike is too small to hold a lag screw and no attempt should be made to lag it.

The T-plate is considerably weaker than a 4.5-mm broad DCP and is not recommended for foals weighing more than 200 kg.\textsuperscript{18,29} A single 4.5-mm broad DCP or two 4.5-mm narrow DCPS placed side by side will increase the strength of the repair considerably and allow placement of 5.5-mm cortical or 6.5-mm cancellous screws in the epiphysis (Figure 10). If soft tissue coverage is adequate, double 4.5-mm plate application should be used whenever possible.\textsuperscript{18} The plates are contoured to the metaphysis and secured distally with 5.5-mm cortical screws before centering the proximal plate hole on the epiphysis and placing a 5.5-mm cortical or 6.5-mm cancellous screw.
The soft tissues over the implants should be meticulously reapposed and a stent bandage placed over the incision for protection after surgery. The use of closed suction drains is not recommended.\textsuperscript{18,29}

In younger foals, the implants should be removed as soon as fracture healing permits to avoid permanent physeal closure.\textsuperscript{18,28,29} In most cases, the implants can be removed in 4 to 8 weeks.\textsuperscript{18,28,29} In older foals, the implants may be left in longer to assure adequate fracture healing or correction of angular limb deviations because the rate of proximal tibial physeal growth is less.\textsuperscript{29}

Foals with Salter-Harris type II fractures of the proximal tibia have a fair to good prognosis for future soundness with surgical treatment.\textsuperscript{18,28,29} Conservative treatment or external coaptation of these fractures offers little hope for any degree of future soundness. The limited soft tissue coverage for the implants available on the medial side of the tibia makes secure tissue apposition and wound protection imperative. Dehiscence of the surgical incision will usually lead to sepsis of the bone and implant failure.\textsuperscript{29} Physeal growth is usually affected to some degree by the injury and subsequent fixation. Proper implant selection and correct application coupled with timely removal will minimize these complications. Minor discrepancies in leg length can be compensated for by alterations in joint angles of the stifle and hock, whereas significant angular limb deformities of the proximal tibia will severely affect normal stifle function.\textsuperscript{29}

**SUMMARY**

Management of stifle fractures in adult horses and foals is challenging. Aggressive management of these patients can result in a successful outcome. Patient signalment and the specific injury will dictate therapeutic options, choice of surgical technique, and implants used.

**REFERENCES**


**ARTICLE #5 CE TEST**

The article you have read qualifies for 1.5 contact hours of Continuing Education Credit from the Auburn University College of Veterinary Medicine. Choose the best answer to each of the following questions; then mark your answers on the postage-paid envelope inserted in *Compendium*.

1. Medial patellar ligament desmotomy combined with early postoperative exercise has been implicated as a cause of
   a. tibial tuberosity fractures.
   b. distal patellar fragmentation.
   c. comminuted patellar fractures.
   d. axial sagittal patellar fractures.

2. Distal patellar fragmentation causing clinical signs of lameness in horses is best managed by
   a. a forced exercise program.
   b. a medial patellar ligament desmotomy.
   c. surgical removal of the fragments through a liberal arthrotomy incision into the femoropatellar joint.
   d. arthroscopically guided fragment dissection and removal.

3. Tibial tuberosity fractures in horses
   a. cause a very mild lameness and minimal swelling over the cranial aspect of the stifle.
   b. are radiographically indistinguishable from an active tibial tuberosity physis in horses younger than 4 years of age.
   c. can be treated conservatively irrespective of articular involvement or degree of displacement.
   d. are often articular and distracted due to the pull of the quadriceps mechanism through the middle patellar ligament.

4. Management of transverse or comminuted patellar fractures in adult horses
   a. requires the use of 5.5-mm cortical screws placed in lag fashion.
   b. does not benefit from tension band wiring to reinforce the lag screw fixation.
   c. does not require internal fixation as they can be managed effectively with stall rest.
   d. requires the use of 3.5-mm cortical screws placed in lag fashion.

5. Proximal tibial Salter-Harris type II physeal fractures in 3- to 6-month-old foals are
   a. managed by placing the limb in a Thomas-Schroeder splint.
   b. managed by internal fixation with cross pins alone. (continues on page 1028)
6. Which of the following statements regarding patellar fractures in horses is true?
   a. Sagittal patellar fractures occur more commonly on the abaxial (lateral) side and should always be managed with internal fixation.
   b. Transverse patellar fractures can be effectively managed with stall rest alone.
   c. Displaced patellar fractures and those with an incongruent joint surface or radiographically measurable fracture gap greater than 5 mm should be treated with internal fixation.
   d. Partial patellectomies to restore athletic soundness are indicated for patellar fragments that encompass up to 50% of the patella and are located on the abaxial (lateral) side.

7. Which of the following is an unlikely etiology of marked lameness and swelling of the stifle region in a foal?
   a. distal femoral Salter-Harris type II physeal fracture
   b. proximal tibial Salter-Harris type II physeal fracture
   c. synovial sepsis of the stifle joint
   d. patellar fracture

8. Which standing radiographic view is necessary to image sagittal fractures or distomedial avulsion fragments of the patella adequately?
   a. lateromedial
   b. caudocranial
   c. caudolateral to craniomedial
   d. dorsoproximal to dorsodistal

9. Conservative therapy of displaced distal femoral or proximal tibial physeal fractures in foals is unlikely to result in
   a. contracture of the affected limb.
   b. angular limb deviations of the contralateral (supporting) limb.
   c. marked discrepancies in leg length, stifle angulation, and joint function.
   d. a successful outcome with a good prognosis for future soundness.

10. Which of the following is unlikely to be successfully managed by any means in a 400-kg adult horse with a reasonable expectation of future soundness?
   a. distal articular patellar fragmentation
   b. tibial tuberosity fracture with an articular component
   c. distal femoral diaphyseal or metaphyseal fracture
   d. femoral condylar fracture involving less than 25% of the caudal aspect of the condyle