

Tibial Spine Avulsion Fracture (TSAF)

About the Anterior Cruciate Ligament (ACL)

There are four main ligaments that stabilize the knee. The ACL is located in the center of the knee along with the posterior cruciate ligament (PCL). The ACL is responsible for stabilizing knee rotation that occurs during cutting and pivoting activities. The ACL is also a secondary restraint to knee hyperextension.

The ACL stabilizes the knee joint in two ways. First, the ligament acts as a passive restraint to excessive movement through its connection to the shin bone (tibia) and thigh bone (femur). Second, the ACL has mechanically sensitive nerve receptors, called proprioceptors, which sense the position of a joint. When a joint starts to exceed its normal range or speed of movement these proprioceptors will send a signal to the brain and spinal cord, which then stimulates the appropriate muscles to assist with stabilizing the joint.

Mechanism of Injury

An ACL injury usually occurs without contact from another player. The most common form of non-contact injury is acceleration injury. An athlete often plants their foot on the ground to cut or change directions and the ACL cannot withstand the force placed on it, so it tears.

This causes the knee to buckle or give out. The ACL also can be torn if the knee is forcefully hyperextended while landing from a jump. An ACL injury causes pain and a lot of swelling in the knee.

In athletes who are still growing (skeletally immature) the bony attachment site (the tibial spine) can be weaker than the ACL. This can cause the injury to be a bony avulsion, or fracture, instead of a ligament tear or rupture. This is called a tibial spine avulsion (TSA) fracture. Although this can cause the knee to feel unstable like an ACL tear, the diagnosis and treatment for this injury is different than an ACL tear.

Diagnosis of a TSAF Injury

There are various classification systems that describe TSAF injuries. The most common is that described by Meyers and McKeever: Type 1 = non-displaced, Type 2 = some displacement but have hinge type component and Type 3 = displaced. After suspicion of the injury based on patient age and mechanism of injury, the diagnosis is confirmed by radiographic (xray) evaluation. Figure 1 shows at type II TSAF.

An MRI may be used to evaluate the meniscus and articular cartilage. There are also times where a CT scan may be used to more closely evaluate the amount of bone in a displaced fracture fragment. (Figure 2)

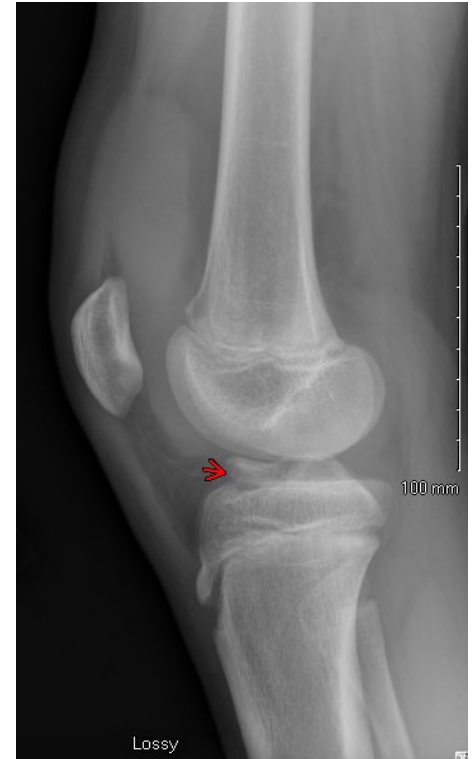


Figure 1: Xray of Type II tibial spine avulsion fracture

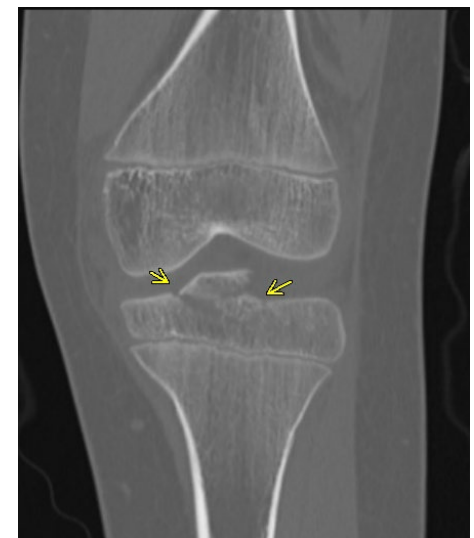


Figure 2: CT of Type III tibial spine avulsion fracture

Consequences of a TSAF

When treating a TSAF injury, the key is controlling the instability of the knee. Repeated instability not only hinders athletic performance, but more importantly increases the risk of further injury to the cartilage and other ligaments of the knee. Cutting and pivoting activities (common in sports like football, soccer, basketball and volleyball) are the most stressful for the ACL and are the activities most likely to reproduce the instability in an athlete with a TSAF that does not heal correctly.

Treatment of TSAF injuries

Type I fractures are usually treated with immobilization. This requires the patient to wear a straight leg knee brace for 6 weeks, then transition into more comprehensive rehabilitation once the bone has healed. Type II fractures typically undergo an initial attempt at closed reduction, meaning trying to get the boney fragment to lie back to its original place. If this isn't successful, then arthroscopic or open reduction and fixation if needed. Type III fractures are indicated directly for arthroscopic surgery, either with suture and/or screw fixation. These fixation techniques hold the boney fragment in place to allow for complete boney healing.

All athletes will undergo six to twelve months of physical therapy. The post-operative physical therapy can be divided into five phases. During the first phase, the rehabilitative goals include protecting the healing fracture, decreasing swelling, and regaining leg muscle control. It is especially important to regain full extension very early post-operatively. In phase two, the goal is to focus on restoring range of motion, proper body alignment and control with basic movements, such as walking, squats, and balance. This phase continues to build lower extremity and core (trunk) strength. In phase three, the focus shifts to developing good movement control with impact activities. Developing movement control and eliminating apprehension while cutting and pivoting is the primary goal of phase four. At this time, there is also more focus on single leg impact and push off with change of direction. The final phase transitions the athlete from performing intense cutting and pivoting activities in a controlled environment to an environment that more closely replicates their sport, including return to team practices with progressive decrease in limitations.

When returning to sports and higher-level activities, there is the risk of the new ACL tearing if there is a new injury to the knee. The risk of this happening likely to do a few different things including continued physical maturation and return to more intense or competitive high-level activity. Due to this risk of re-injury, your physical therapist and doctor will put you through a series of progressive tests to determine when it is most safe to return to activity and sports. There is good evidence to show that the risk of re-injury goes down significantly by passing all return to sport testing.

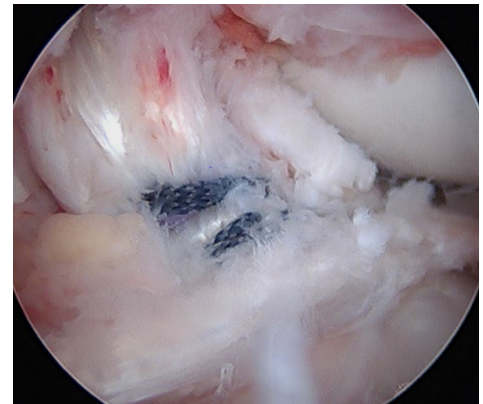


Figure 3: Sutures compressing the TSAF back to its original location

Tibial Spine Avulsion Fracture (TSAF) Surgical Fixation

PHASE I (surgery to 6 weeks after surgery)

Appointments	<ul style="list-style-type: none"> Rehabilitation appointments begin post-op day 1 (afternoon as patient may be kept overnight at American Family Children's Hospital) and should be 1-2 times per week during this phase.
Rehabilitation Goals	<ul style="list-style-type: none"> Protection of healing graft fixation Restore quadriceps function and leg control Adherence to home exercise program (HEP) and precautions
Precautions	<p><u>Weightbearing:</u> Touch-down weight bearing (TDWB) for 2 weeks with crutches, then weeks 3-6 partial weight bearing (PWB) with crutches (max 50% BW)</p> <p><u>Brace:</u> Post-operative brace locked in extension for 6 weeks, then wean from brace after 6 weeks</p> <p><u>Range of Motion:</u></p> <ul style="list-style-type: none"> weeks 1-2: 0-30° weeks 3-4: 30-60° weeks 5-6: 60-90° NOTE: Staying within the range of motion guidelines is imperative to protect the periosteal stitch on the tibia <p><u>Meniscal Repair:</u></p> <ul style="list-style-type: none"> No weightbearing flexion x 4 weeks, respect and don't push through any compression type pain or discomfort when working on flexion range of motion <p><u>Meniscal ROOT Repair:</u></p> <ul style="list-style-type: none"> Touch-down weight bearing (TDWB) in locked extension brace for 6 weeks. NWB flexion for 6 weeks ROM 0-90 degrees, always in NWB position
Suggested Therapeutic Exercise	<ul style="list-style-type: none"> Assisted seated knee flexion for range of motion (ROM) within above guidelines Knee extension range of motion (avoid hyperextension past 5°) Ankle pumps progressing to resisted ankle ROM Patellar mobilizations - especially superior mobilizations to minimize adhesions within the fat pad Quad sets Hamstring sets Straight leg raises
Cardiovascular Exercise	<ul style="list-style-type: none"> None at this time

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Progression Criteria	<ul style="list-style-type: none"> • 6+ weeks AND: <ol style="list-style-type: none"> 1. Good quad set and open chain leg control 2. Full knee extension 3. Near normal gait without crutches 4. Minimal knee effusion
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PHASE II (begin after meeting Phase I criteria, usually 6 weeks after surgery)

Appointments	<ul style="list-style-type: none"> • Rehabilitation appointments are 1-2 times per week
Rehabilitation Goals	<ul style="list-style-type: none"> • Normalize gait • Avoid overstrengthening the fixation site • Closed chain leg control for non-impact movement control • Adherence to HEP

Precautions	<ul style="list-style-type: none"> • Weight bearing as tolerated • Gradual progression to full knee flexion ROM • Avoid over-loading the fixation site by utilizing low amplitude low velocity movements. • No active inflammation or reactive swelling.
ROM Exercises	<ul style="list-style-type: none"> • Supine wall slides, heel slides and knee to chest to gradually improve knee flexion • Stationary bike with low resistance • Aquatic therapy as needed
Suggested Therapeutic Exercise	<ul style="list-style-type: none"> • Gait drills - forward and backward march walk, soldier walk, side step, step overs, hurdle walk • Double leg balance drills - balance board, tandem balance • Closed chain strengthening for quadriceps and glutes - double leg squat progressions, split squats, step backs, leg press • Bridging • Balance board drills - double leg balance • Hip and core strengthening
Cardiovascular Exercise	<ul style="list-style-type: none"> • Stationary bike with low resistance • Deep water running • Elliptical trainer
Progression Criteria	<ul style="list-style-type: none"> • Normal gait • Symmetric weight acceptance for squats to 60° • No reactive swelling after exercise or activity that lasts for more than 12 hours.

Phase III (begin after meeting Phase II criteria, usually 12-14 weeks after surgery)

Appointments	<ul style="list-style-type: none"> • Rehabilitation appointments as needed. Usually every 1-2 weeks.
Rehabilitation Goals	<ul style="list-style-type: none"> • Continued Quadriceps and hamstring strength building <ul style="list-style-type: none"> - restoring symmetry, hamstring:quadriceps ratio 60%, and strength relative to body weight • Normal running gait without side-to-side differences or compensations. • Normal double leg landing control without side-to-side differences or compensations for sub-maximal squat jump. • Adherence to HEP
Precautions	<ul style="list-style-type: none"> • No active reactive swelling or joint pain that lasts more than 12 hours.
Suggested Therapeutic Exercise	<ul style="list-style-type: none"> • Low amplitude low velocity agility drills; forward and backward skipping, side shuffle, skater’s quick stepping, carioca, cross overs, backward jog, forward jog • Closed chain strengthening for quadriceps and glutes – progressing from double leg strengthening to single leg strengthening; lunge progressions and single leg squat progressions <ul style="list-style-type: none"> - Emphasis on controlling forward knee position to ensure athlete is not compensating for quadriceps weakness • Open chain strengthening for quadriceps isolation <ul style="list-style-type: none"> - continue progressive overload, may need to limit ROM to allow higher RPE during exercise due to length tension relationship of quadriceps (i.e. knee extension 90-30 deg) • Single leg balance exercise and progressions, progressing from stationary to deceleration in to holding posture and position

	<ul style="list-style-type: none"> • At ~12-14 weeks initiate low amplitude landing mechanics: med ball squat catches, shallow jump landings, chop and drop stops, etc. • Hip strengthening – especially oriented at neuromuscular control in prevention of hip adduction and landing stance • Core strength and stabilization – especially orientated at preventing frontal plane trunk lean during landing and single leg stance <p>NOTE: neurocognitive strategies and external focus of attention should be utilized with the therapeutic exercises. Examples:</p> <ol style="list-style-type: none"> 1. Dual task activities 2. Using foam rollers or bench/chair for biofeedback about hip and knee position 3. Using PVC pipe or bar for trunk lean and/or weight shifting 4. Reactive challenge <ol style="list-style-type: none"> a. One step challenges to start (i.e. when I say “Go” do a lunge”) b. Progressing to Multi-Step or decision making (if I say “1” do a forward lunge, if I say “2” do a lateral lunge) c. Using color cues via fit lights or blaze pods as able, SwitchedOn (free app) for visual prompts, or therapist created drills with balls/cones of different colors <ul style="list-style-type: none"> • <i>If patients are still demonstrating arthrogenic muscle inhibition or torque unsteadiness it is suggested to use NMES, see addendum for guidelines and parameters</i>
Cardiovascular exercise	<ul style="list-style-type: none"> • Stationary bike with moderate resistance <ul style="list-style-type: none"> - Interval training to match sport demands as appropriate (see addendum for guidelines) • Deep water running and swimming • Elliptical trainer at moderate intensity <p>Return to jog program should not be utilized as cardiovascular training, just movement re-training and impact progression.</p>
Progression criteria	<ul style="list-style-type: none"> • Normal jogging gait • Good single leg balance • Less than 25% deficit on Biodex strength test --- ready to start impact loading. if patients have NOT achieved >75% quadriceps symmetry: they should NOT progress impact drills to protect their joint surfaces from excessive compressive force - Continue strength progression, rate of force development and speed work without impact. • No reactive swelling after exercise or activity

PHASE IV (begin after meeting Phase IV criteria, usually 20-24 weeks after surgery)

Rehabilitation appointments	<ul style="list-style-type: none"> Rehabilitation appointments are once every 2-3 weeks
Rehabilitation goals	<ul style="list-style-type: none"> Normal multi-planar high velocity without side-to-side differences or compensations. Normal double leg and single leg landing control without side-to-side differences or compensations Running without a limp Adherence to HEP
Precautions	<ul style="list-style-type: none"> No active reactive swelling or joint pain that lasts more than 12 hours.
Suggested therapeutic exercises	<ul style="list-style-type: none"> Progressive agility drills; forward and backward skipping, side shuffle, skater’s quick stepping, carioca, cross overs, forward jog, backward jog – increase amplitude and velocity Landing mechanics – progressing from higher amplitude double leg to sling leg landing drills. Start uni-planar and gradually progress to multi-planar. Start with vertical challenges and drills prior to horizontal challenges and drills. Movement control exercise beginning with low velocity, single plane activities and progressing to higher velocity, multi-plane activities Unanticipated movement control drills, including cutting and pivoting Agility ladder drills Strength and control drills related to sport specific movements. Sport/work specific balance and proprioceptive drills Hip strengthening – especially orientated at neuromuscular control in prevention of hip adduction and landing stance Core strength and stabilization- especially orientated at preventing frontal plane trunk lean during landing and single leg stance Stretching for patient specific muscle imbalances <p><u>NOTE:</u> neurocognitive strategies and external focus of attention should be utilized with the therapeutic exercises. Examples:</p> <ul style="list-style-type: none"> Dual task for cognitive distraction Single step cues/reactions: verbal or visual to promote visual scanning of outside environment Multi-step commands: using color or number patterns

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	<ul style="list-style-type: none">• Partner reaction and competition to increase speed and effort• Cognitive challenges during movement or stabilization, such as quick math problems, counting backward, word association games, etc• <i>If patients are still demonstrating arthrogenic muscle inhibition or torque unsteadiness it is suggested to use NMES, see addendum for guidelines and parameters</i>
Cardiovascular exercise	<ul style="list-style-type: none">• Progressive running program. Design to use sport specific energy systems
Progression criteria	<ul style="list-style-type: none">• Progressive testing will be completed. The patient should have less than 20% difference in Biodex strength test• Normal multi-planar low to medium velocity without side- to-side differences or compensations.• Normal double leg landing control without side-to-side differences or compensations• Running without a limp

PHASE V (begin after meeting Phase IV criteria, usually 26-28 weeks after surgery)

Rehabilitation appointments	<ul style="list-style-type: none"> • Physician appointment 9 months after surgery (if needed) • Rehab every 2-3 weeks
Rehabilitation goals	<ul style="list-style-type: none"> • Sprint without a limp • Confidence and control with cutting and pivoting activities • Confidence and control with single leg plyometrics, including good mechanics • Graduated return to sport and work
Precautions	<ul style="list-style-type: none"> • Post-activity soreness should resolve within 24 hours • Avoid post-activity swelling
Suggested therapeutic exercises	<ul style="list-style-type: none"> • Progressing effort and complexity of hopping <ul style="list-style-type: none"> - Addition of multi-planar hop - Progress number of hops in a row emphasizing decreased ground contact time • Practice of cutting and pivoting, other change of direction <ul style="list-style-type: none"> - Starting with planned, wide cuts (open angle) gradually decreasing angle of cuts (sharper turns) progressing effort and speed - Add multiple pre-planned cuts in a row - Change of direction from forward run to drop step and vice versa - Gradually progressing from closed drills to open cutting drills under self-direction - Advancing reactive nature of cutting with visual and verbal cues - Promote visual scanning and reaction to sports-specific cues • Gradual re-introduction (<i>see practice continuum in references below</i>) <p>NOTE: neurocognitive strategies and external focus of attention should be utilized with the therapeutic exercises. Examples:</p>

	<ol style="list-style-type: none"> 1. Using verbal or visual cues for “stop and go” 2. Color cues to indicate different types of cuts (different angles) 3. Partner led sports-specific defesive runs with cutting and change of direction 4. Task change on a cue with an additional task cue 5. Layering in multi-step commands utilizing visual scanning and neurocognitive challenge (decision makin)
Cardiovascular exercise	<ul style="list-style-type: none"> • Replicate sport/work specific energy demands • Limited practice activities
Progression criteria	<ul style="list-style-type: none"> • Patient may return to sport after receiving clearance from the orthopedic surgeon and the physical therapist/athletic trainer. Progressive testing will be completed. The patient should have less than 10% difference in Biodex strength test, force plate jump and vertical hop tests, and functional horizontal hop tests.

NMES Suggested Treatment Parameters:

- Indications: poor quad activation or lack of torque steadiness at higher loads
- Amplitude/Intensity (mA): as high as patient can tolerate
- Pulse Width (μ s): 100-400 μ s
- Pulse Rate (Hz): 50-100 Hz
- Frequency: NMES should be dosed the same way you would dose quadriceps strengthening exercise; early in the rehabilitation process, this should be used every day or even multiple times a day. As the patient progresses and the intensity of their exercise increases, the frequency will likely change to 2-4 times a week.

Practice Continuum:

1. Movement Patterns: a. sprinting b. shuffle c. carioca d. zig-zag cutting and e. shuttle change of direction
2. Closed Drills – sport-specific drills without opposition in a controlled speed environment
3. One-on-one Drills (no-contact) – sport-specific drills/ activities where the athlete is expected to react to his/her opponent without compensation
4. One-on-one Drills – full speed 1 on 1 drills with game necessary contact
5. Team Scrimmage (no-contact) – patients are asked to wear a different colored jersey to indicate their contact
6. restrictions during team scrimmaging when appropriate
7. Team Scrimmage – full scrimmaging
8. Restricted Play – progressing time and situational play as appropriate.
9. Full return to play

Patient may return to sport after receiving clearance from the surgeon and the physical therapist/athletic trainer. Progressive testing will be completed. Patient should have less than 10% difference in Biodex strength test, force plate jump and hop tests and functional hop tests.

References:

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These rehabilitation guidelines were developed collaboratively by UW Health Sports Rehabilitation and the UW Health Sports Medicine physician group.

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