



Main Line Health[®]

Orthopaedics & Spine

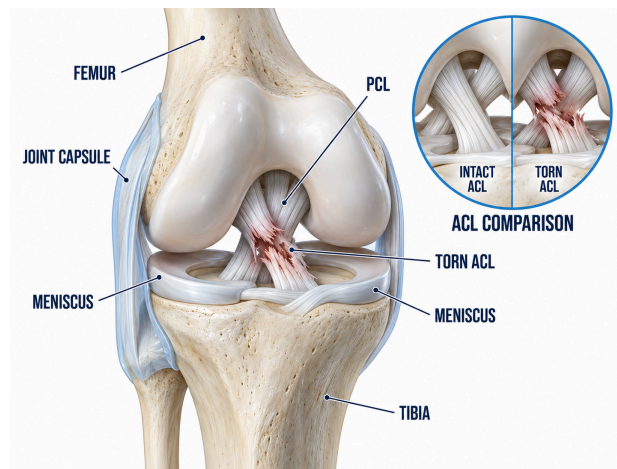
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ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION

Understanding the Injury

The anterior cruciate ligament (ACL) is one of four major ligaments that stabilize the knee joint, connecting the femur (thighbone) to the tibia (shinbone). It prevents the tibia from sliding too far forward beneath the femur and provides the rotational stability needed for cutting, twisting, pivoting, and jumping.

An ACL tear frequently occurs alongside injury to the meniscus (shock-absorbing cartilage pads), the articular cartilage, or the medial collateral ligament (MCL).



The most common mechanism is a sudden deceleration combined with a rotational force — no contact is required. Landing from a jump with the knee collapsing inward, planting and pivoting, or a direct blow to the knee are common scenarios. At the moment of injury, patients typically hear or feel a "pop," followed by swelling within two hours, instability, and difficulty bearing weight.

If the ACL is not reconstructed, the knee often regains motion and is relatively pain-free after 6 to 8 weeks, but it remains unstable for pivoting activities. In young, active patients, repeated episodes of the knee giving way can damage the menisci and articular cartilage, leading to progressive joint problems.

Diagnosis of an ACL Tear

Diagnosis is made through a combination of your history, physical examination (Lachman test, anterior drawer, pivot shift), plain X-rays to rule out a fracture, and MRI to confirm ligament status and assess the meniscus, cartilage, and other structures. Your surgeon will review all findings before recommending a treatment plan.

Do You Need Surgery?

Patients who are older, relatively inactive, and willing to avoid high-demand pivoting sports may function adequately without reconstruction, using dedicated physical therapy and a functional knee brace to compensate for the absent ACL. However, repeated giving-way episodes carry a risk of further meniscus and cartilage damage.

For most active individuals, surgical reconstruction is the recommended course of treatment to restore stability and prevent further joint injury.

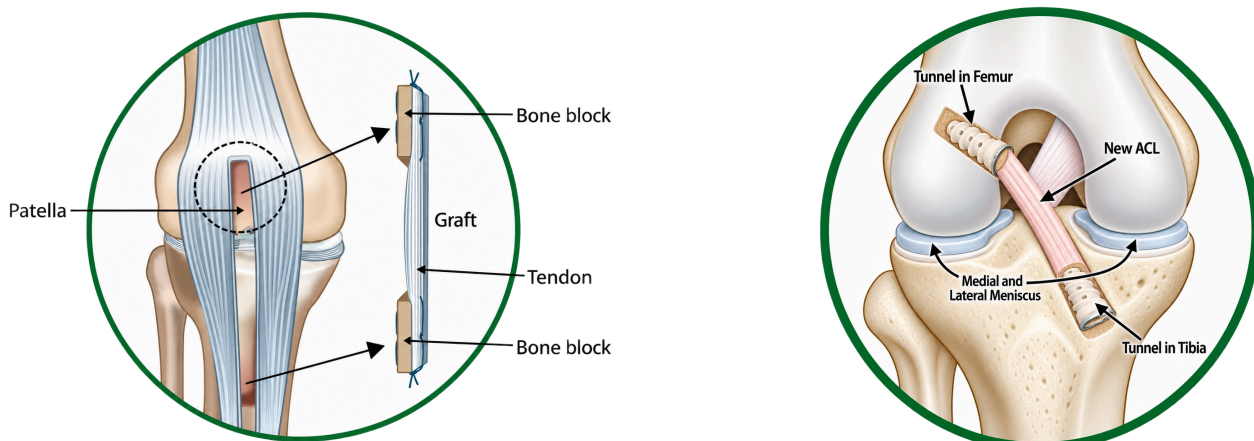
ACL Reconstruction Surgery

Surgical reconstruction replaces the torn ACL with a graft placed arthroscopically through small incisions. Bone tunnels are created in precise positions in the femur and tibia, the graft is passed through the tunnels, and fixation devices secure it in place while healing occurs.

Your reconstruction will use a bone-patellar tendon-bone (BTB) autograft, the central third of your own patellar tendon, harvested with small bone plugs from the kneecap and upper tibia. This is considered the gold-standard graft for active patients: bone-to-bone healing is faster and more reliable, the graft closely replicates the native ACL's strength, and long-term data support excellent outcomes and low re-rupture rates in athletes. A small area of numbness near the incision is a normal, expected consequence of graft harvest and usually resolves over 1 to 2 years.

Surgery is best performed once the acute phase of injury has resolved, typically 3 to 6 weeks after injury, after a course of “prehabilitation” to restore full motion, especially full knee extension, one of the strongest predictors of a good outcome.

Expected Outcomes and Surgical Risks



Benefits of surgical reconstruction include restoration of knee stability for work, daily activity, and sport; prevention of further meniscus and cartilage injury; and return to unrestricted athletic activity.

Potential risks and complications include:

Permanent numbness near the incision — expected with the BTB graft

Kneecap pain or irritation, and loss of full extension: each approximately 5–10%

Graft failure or re-rupture: approximately 5–10%

Persistent swelling: approximately 10%

Wound infection, blood clot, or nerve injury: each less than 1%

Return-to-activity timelines are guidelines — walking without crutches in 2 to 4 weeks, jogging at 3 to 4 months, and full unrestricted return to sport at 9 to 12 months — with advancement determined by strength testing and clinical criteria, not calendar time alone.

PRE-OPERATIVE INSTRUCTIONS

Surgery Preparation Guide

Your preparation before surgery plays an important role in a smooth procedure and recovery. Please review the timeline below carefully.

Several Weeks Before Surgery.

(As directed by Dr. Fliegel and the surgical team)

- Attend your pre-operative visit for a full history, physical examination, and surgical counseling.
- Begin “prehabilitation”: use a stationary bicycle daily and focus on achieving full, symmetric knee extension before your surgical date.
- Establish care with a physical therapist before surgery if possible.

Arrange your home: confirm CPM machine delivery, ice supply, crutches, and a shower stool are in place before surgery.

Several Days Before Surgery.

- Wash the knee and leg with Hibiclens (chlorhexidine) surgical soap twice daily for 3 days before surgery.
- Avoid cuts, scrapes, sunburn, or any skin irritation near the knee. Do not shave the surgical area.

The Day Before Surgery.

- Confirm your hospital arrival time with our office.

- Arrange for a responsible adult to drive you home and stay with you for the first 24 hours.

The Day of Surgery.

- Bring any MRI, CT, or X-ray studies performed outside our system.
- Bring your knee brace and crutches if previously provided.
- Bring insurance cards, photo identification, a list of your current medications, and loose-fitting shorts that will fit over a knee brace.

ACL RECONSTRUCTION REHABILITATION PROTOCOL

This protocol is a guideline for both patients and physical therapists. Progression from one phase to the next is determined by meeting criteria, not calendar time alone. Please provide your physical therapist with a copy of this protocol.

The primary goals are to:

Protect the graft while it heals

Restore full knee extension and progressive flexion

Reduce swelling and restore quadriceps control

Rebuild strength, balance, and neuromuscular control

Safely return to work, recreational, and sport activity

PHASE I: IMMEDIATE POST-OPERATIVE (0–2 Weeks)

Goals

- Protect the reconstruction – avoid falls and uncontrolled pivoting
- Restore full passive knee extension equal to the contralateral side
- Achieve flexion to 90° by end of week 1, 100–120° by end of week 2
- Reduce swelling and pain; establish quadriceps activation

Immobilization

- Weight bearing as tolerated with crutches from Day 1
- Brace set at 0–90° during ambulation
- CPM machine a minimum of 10 hours per day; do not place a pillow under the knee

Range of Motion (Protected)

- Patellar mobilization, heel prop, prone hang, and heel slides to restore full extension
- Do NOT allow a flexion contracture to develop – this is one of the most preventable complications after ACL reconstruction

Exercises

- Quadriceps sets and straight leg raises
- Ankle pumps and hip abduction
- Ice 15–20 minutes every 1–2 hours; compression stocking worn continuously

Advancement Criteria

- Non-antalgic gait pattern
- Full passive knee extension equal to contralateral side
- Knee flexion 90° or greater
- Good quadriceps set with visible terminal knee extension
- Sutures removed at 2-week visit

PHASE II: EARLY STRENGTHENING (2–6 Weeks)

Goals

- Protect the graft – avoid falls, pivoting, and varus/valgus stress
- Maintain full extension; achieve flexion 125° or greater
- Normalize gait without crutches; begin strengthening

Immobilization

- Progress to full weight bearing; discontinue crutches once gait is normalized
- Brace may be discontinued at the 6-week surgeon visit

Range of Motion

- Continue Phase I range-of-motion work
- Stationary bicycle 5–7 days per week, 10–15 minutes
- Begin gentle hamstring, quadriceps, and calf stretching

Strengthening

- Mini squats and wall slides, 0–60° only
- Standing hamstring curl and toe raises
- Hip abduction and lumbopelvic strengthening (bridges, clamshells)
- Begin single-leg balance and proprioception training

Precautions

- Avoid falls, pivoting, and varus/valgus stress on the knee
- No running, jumping, or resisted machines until criteria are met

Advancement Criteria

- Normal gait without brace
- Full passive extension; flexion greater than 125°
- Full straight leg raise without extension lag
- No increase in pain or swelling

PHASE III: PROGRESSIVE STRENGTHENING (6–12 Weeks)

Goals

- Maintain full ROM equal to the contralateral side
- Safely progress closed-chain lower extremity strengthening
- Initiate single-leg strengthening; improve proprioception

Range of Motion

- Discontinue brace at the 6-week visit unless directed otherwise
- Walk with a normal heel-to-toe gait; no running, jumping, or pivoting yet

Strengthening

Leg press, hamstring curl machine, wall slides, squat to chair

Step-up/step-down progression (3 to 6 to 9 inches)

Single-leg wall slide, calf raises, hip abductor/adductor work

Begin double-limb plyometrics near week 12 (mini-trampoline hops, jump rope), limited to 60 foot contacts, 2 times per week

Precautions

- No running, jumping, Stairmaster, or pivoting until criteria are met

Advancement Criteria

- Full ROM equal to contralateral side
- Single-leg step-down, wall slide, and squat at 60° x 5 reps with good form
- Jog 100 feet without a limp; quadriceps strength approximately 80% of contralateral side

PHASE IV: ADVANCED STRENGTHENING AND RUNNING (12–16 Weeks)

Goals

- Regain full symmetrical lower extremity strength
- Advance plyometric training to double-limb directional hops
- Begin a structured running program with surgeon clearance

Strengthening

- Continue Phase III strengthening with heavier resistance, fewer reps
- Add dumbbell resistance to squats and wall slides
- Avoid the knee extension machine, deep lunges, squats past 90°, and Stairmaster until cleared

Weight Training Guidelines

- Begin on soft, flat surfaces, 3 times per week, once quadriceps strength is approximately 80% of contralateral side and you can jog 100 feet without a limp
- Week 1: 3 sessions of 10-minute jogging; increase by 1 minute per session as tolerated, to a maximum of 30 minutes

Avoid

- Double-limb forward and side-to-side hops, broad jumps, and jump rope – limited to 90 foot contacts, 2 times per week

PHASE V: AGILITY AND RETURN TO SPORT (16 Weeks – 9+ Months)

Goals

- Advance to structured speed, agility, and direction-change training
- Advance plyometrics to single-limb and multi-plane tasks
- Achieve full, unrestricted return to sport with symmetrical performance

Progression

- Straight-ahead running progressing to full-speed sprints (weeks 16–20)
- Direction-change running – zig-zag, backward, figure-8, carioca (weeks 20–24)
- Hard cutting and pivoting introduced around 7 months once all criteria are met
- Non-contact practice, then full contact practice, then full competition

Return-to-Sport Criteria

- Single-leg hop, timed hop, triple hop, and crossover hop within 15% of the contralateral side
- Quadriceps, hamstring, and glute strength at least 90% of contralateral side
- KOOS-Sports and IKDC questionnaire scores meeting threshold; surgeon clearance obtained

Key Rehabilitation Principles

- Continue single-leg strength and neuromuscular training indefinitely – re-injury risk is highest in the first 2 years after surgery, so long-term maintenance work is the best protection for your graft.
- Activities to avoid until cleared: open-chain knee extension against resistance, running before Phase IV criteria are met, jumping before the plyometric progression, and pivoting or cutting before Phase V.
- Contact our office for fever, increasing redness or drainage from the incision, significant calf swelling or pain, uncontrolled pain, or inability to straighten the knee.
- Please arrange to return to Dr. Fliegel's office 7 to 10 days after surgery.



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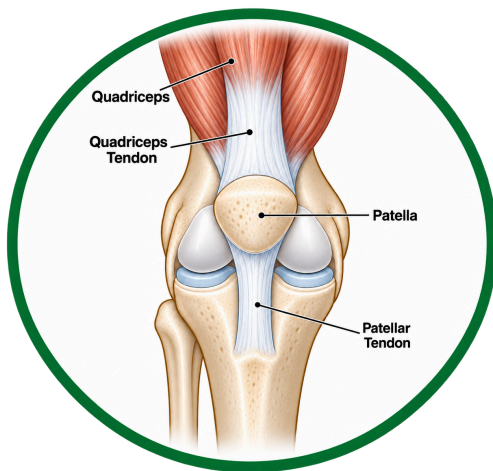
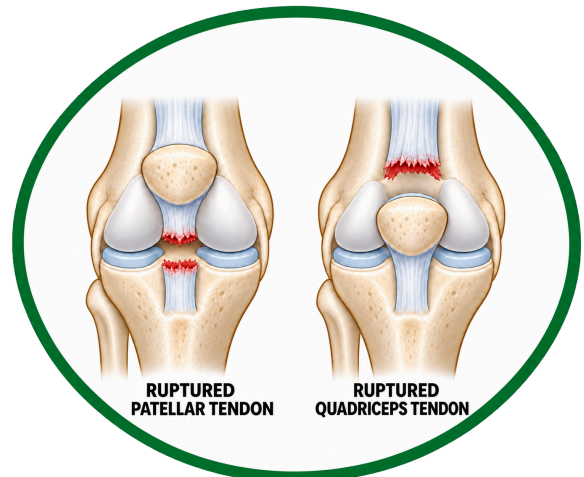
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PATELLAR/QUADRICEPS TENDON REPAIR

Understanding the Injury

The patellar tendon connects the bottom of the patella (kneecap) to the tibial tubercle on the front of the tibia (shinbone). At the top of the patella, the quadriceps tendon attaches the patella to the quadriceps muscle on the front of the thigh. As the quadriceps muscle contracts, it pulls through the quadriceps tendon, the patella, and the patellar tendon to straighten (extend) the knee; as the muscle relaxes, the knee is able to bend (flex).



When the patellar tendon ruptures, the patella loses its anchor to the tibia and is pulled upward, toward the hip, by the quadriceps muscle. When the quadriceps tendon ruptures, the patella loses its anchor to the thigh and drops downward, toward the foot. In either case, the quadriceps muscle can no longer hold the knee straight — patients typically cannot actively extend the knee, and the knee buckles or gives way when they try to stand or bear weight. These injuries most often result from a sudden, forceful quadriceps contraction against a bent knee, such as landing awkwardly from a jump, stumbling, or a fall.

Diagnosis of a Patellar or Quadriceps Tendon Tear

Diagnosis is made through history and physical examination. Palpating the tendons and patella typically reveals a gap at the site of the tear, along with an abnormally high-riding patella (patellar tendon rupture) or low-riding patella (quadriceps tendon rupture). X-rays

confirm the abnormal position of the patella, and an inability to actively straighten the knee against gravity is a hallmark finding.

Do You Need Surgery?

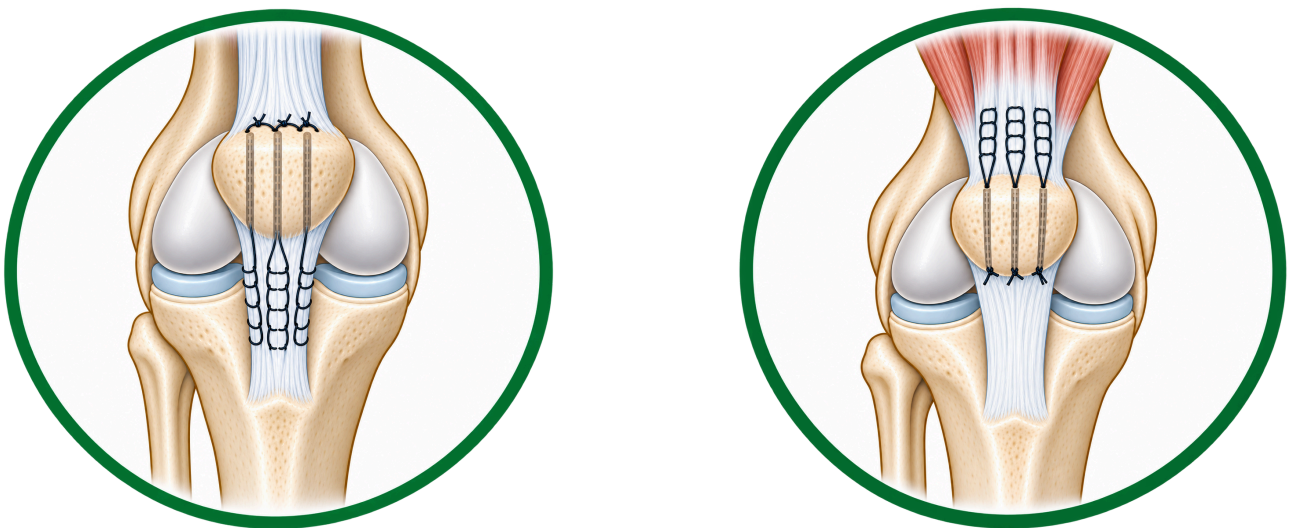
Because the tendon lies outside the joint, a complete rupture cannot heal on its own or be repaired arthroscopically. Without surgical repair, the quadriceps mechanism cannot be restored and the knee remains unable to actively extend, so nearly all complete ruptures require surgery. A partial tear with preserved active extension may occasionally be managed non-operatively, at your surgeon's discretion.

Patellar/Quadriceps Tendon Repair Surgery

Repair is usually performed as an outpatient procedure or with a short overnight stay. An incision is made on the front of the knee over the site of the rupture, the torn tendon ends are identified, and the tendon is sewn back together, often reinforced with sutures anchored through bone tunnels in the patella or tibial tubercle.

Because the repair must protect a tendon under continuous tension from the quadriceps muscle, a knee immobilizer or hinged brace locked in extension is worn for a minimum of 6 weeks, with weight bearing and knee motion advanced gradually and deliberately throughout early rehabilitation.

Expected Outcomes and Surgical Risks



Benefits of surgical repair include restoration of the extensor mechanism, return of the ability to actively straighten the knee, and the best chance of regaining full strength and function.

Potential risks and complications include:

Failure of the repair or re-rupture, requiring further surgery

Stiffness or loss of motion

Suture reaction or persistent pain at the repair site

Infection, blood clot (including pulmonary embolus), or nerve injury

Persistent weakness after the injury and repair

Most patients regain good knee function when the protective rehabilitation protocol below is followed closely, since the repair's success depends heavily on protecting the tendon while it heals – recovery is typically slower than after many other knee procedures.

PRE-OPERATIVE INSTRUCTIONS

Surgery Preparation Guide

Your preparation before surgery plays an important role in a smooth procedure and recovery. Please review the timeline below carefully.

Several Weeks Before Surgery

(As directed by Dr. Fliegel and the surgical team)

- Attend your pre-operative visit for a full history, physical examination, and surgical counseling.
- Begin gentle range-of-motion and quadriceps activation exercises as directed, to optimize knee function before surgery.
- Establish care with a physical therapist before surgery if possible.

Arrange your home: confirm your knee brace, crutches, ice supply, and a shower stool are in place before surgery.

Several Days Before Surgery

- Wash the knee and leg with Hibiclens (chlorhexidine) surgical soap twice daily for 3 days before surgery.
- Avoid cuts, scrapes, sunburn, or any skin irritation near the knee. Do not shave the surgical area.

The Day Before Surgery

- Confirm your hospital arrival time with our office.
- Arrange for a responsible adult to drive you home and stay with you for the first 24 hours.

The Day of Surgery

- Bring any MRI, CT, or X-ray studies performed outside our system.
- Bring your knee brace and crutches if previously provided.
- Bring insurance cards, photo identification, a list of your current medications, and loose-fitting shorts that will fit over a knee brace.

PATELLAR/QUADRICEPS TENDON REPAIR REHABILITATION PROTOCOL

This protocol is a guideline for both patients and physical therapists. Progression from one phase to the next is determined by meeting criteria, not calendar time alone. Please provide your physical therapist with a copy of this protocol.

The primary goals are to:

Protect the repair while it heals

Control pain and swelling

Restore full knee extension and progressive flexion

Restore quadriceps control and leg strength

Safely return to work, recreational, and sport activity

PHASE I: MAXIMUM PROTECTION (0–2 Weeks)

Goals

- Control pain and swelling
- Protect the tendon repair
- Activate the quadriceps muscle
- Begin weight bearing as tolerated with the brace locked in extension

Immobilization

- Brace locked in full extension for all activity, including walking and sleeping, as directed by Dr. Fliegel
- Weight bearing as tolerated on crutches, with the brace locked in full extension

Range of Motion (Protected)

- The knee remains locked in full extension (straight) in the post-op brace at all times
- No active or passive knee flexion exercises are performed during this phase
- The brace may only be unlocked or removed for bathing, as directed by Dr. Fliegel

Exercises

- Quadriceps sets, holding 5 seconds each: 20 repetitions, 3 times a day
- Ankle pumps at least 10 times each hour to help prevent blood clots
- Wear an elastic (TED) stocking below the knee when out of bed until your first post-operative visit

Advancement Criteria

- Sutures removed and incision healing well
- Good quadriceps activation with the knee in extension
- Pain-free ambulation with the brace locked in extension

PHASE II: PROTECTED MOTION (2–6 Weeks)

Goals

- Protect the tendon repair while beginning controlled motion
- Regain knee flexion, limited to 90°
- Continue building quadriceps strength and control
- Progress toward weaning off crutches

Immobilization

- Continue wearing the brace for all walking, locked in full extension; may be unlocked to sit or exercise only as directed by Dr. Fliegel

Range of Motion

- Do not bend the knee beyond 90° to avoid placing excess stress on the tendon repair
- Heel props, heel slides, and sitting knee flexion, working toward but not past 90°
- Continue the CPM machine if provided, per Dr. Fliegel's instructions

Strengthening

- Continue quadriceps sets, 20 repetitions, 3 times a day
- Straight leg raises (side-lying hip abduction), 20 repetitions, once or twice a day
- Standing toe raises with the brace on, using a table for balance, 20 repetitions
- Ankle pumps at least 10 times each hour

Precautions

- Do not bend the knee past 90°
- Avoid any unbraced weight bearing or unsupported standing

Advancement Criteria

- Comfortable weight bearing with good quadriceps control
- Knee flexion approaching 90° without pain
- No increase in swelling with activity

PHASE III: PROGRESSIVE STRENGTHENING (6–12 Weeks)

Goals

- Walk normally without an assistive device
- Continue regaining and improving knee range of motion
- Begin more advanced muscle-strengthening exercises

Range of Motion

- Continue progressing knee flexion under your surgeon's and therapist's direction

- Begin weaning from the brace as instructed by Dr. Fliegel; if walking without it, use a cane or one crutch on the side opposite the operated knee in case of a stumble

Strengthening

Stationary bicycle with no resistance for 10 to 20 minutes daily, once a full pedal revolution is possible

Straight leg raises, short-arc quad sets, hip abduction, and standing toe raises

Wall slides, bearing about 50% of your weight on each leg, lowering only to about 45° of knee bend

Precautions

- Avoid squatting, deep knee bends, and lunging movements; do not attempt stairs yet
- Avoid stair-stepper machines and any exercise that causes crunching, clicking, or pain at the kneecap

Advancement Criteria

- Normal, non-limping gait on level surfaces
- Full weight bearing without an assistive device
- Good quadriceps control through the available range of motion

PHASE IV: ADVANCED STRENGTHENING (12–20 Weeks)

Goals

- Walk without a brace or crutches, on level surfaces and eventually stairs
- Regain full, symmetric range of motion and progressive strength
- Advance functional strengthening while continuing to protect the repair

Strengthening

- Squat-to-chair exercise and wall slides; may add light dumbbells (3–5 lb, increasing 2–3 lb per week up to 10 lb per hand) after the first week of this phase
- Step-up/step-down progression, starting with a 3-inch step and advancing to 6 and then 9 inches as tolerated
- One-legged toe raises, building to 3 sets of 15 repetitions
- Stationary bicycle with mild resistance for up to 10 minutes daily; swimming is also a good option if available
- Hamstring, quadriceps, and calf stretching, holding each 15–20 seconds

Optional Gym Exercises (16+ Weeks, if Approved)

- Seated leg press, resisted hamstring curls, hip abductor/adductor machine, roman chair, and calf raise machine: 3 sets of 15 repetitions, 3 times a week
- If gym equipment is unavailable, continue straight leg raises, side-lying hip abduction, standing hamstring curls, and toe raises using ankle weights, starting at 1 pound and

adding 1 pound per week

Avoid

- Pain at the tendon repair site or crepitus at the kneecap
- Knee extension weight machines, lunges, stair master, step exercises with impact, running, jumping, pivoting, or cutting

PHASE V: RETURN TO RUNNING AND SPORT (20+ Weeks)

Goals

- Safely progress from walking to running and, ultimately, sport-specific activity
- Restore strength and control comparable to the uninjured side
- Provide objective criteria for a safe return to activity

Progression

- Walk-to-jog progression on a soft, level surface, gradually advancing distance and pace as tolerated
- Progressive running, speed work, and agility drills once jogging is pain-free and well tolerated
- Jump training may begin no sooner than 24 weeks after surgery, and only as directed by Dr. Fliegel

Return-to-Sport Criteria

- Quadriceps strength within 90% of the uninjured side
- Pain-free running, agility, and jumping mechanics
- Hop testing comparable to the uninjured side
- Cleared by Dr. Fliegel to proceed gradually and with caution back to sport

Key Rehabilitation Principles

- Protecting the tendon repair takes priority throughout rehabilitation — the repair is under continuous tension from the quadriceps muscle, and the brace, weight-bearing, and flexion restrictions in Phases I through III exist specifically to protect it while healing occurs; recovery is typically slower than after many other knee procedures.
- Avoid squatting, deep knee bends, lunging, running, jumping, and pivoting or cutting on the knee until cleared, and progress each phase based on meeting the stated criteria rather than by the calendar alone.
- Contact our office for fever, increasing redness or drainage from the incision, significant swelling or pain, an inability to actively straighten the knee, or inability to bear weight.
- Please arrange to return to Dr. Fliegel's office 10 to 14 days after surgery, again at 6 weeks, and again at 3 to 4 months.

