

DR MATTHEW BROADHEAD

Orthopaedic Surgeon · Sydney & Coffs Harbour

ACL Injury & Reconstruction

A guide for patients who have torn their anterior cruciate ligament

This booklet is general information to read at your own pace. It is not medical advice and does not replace a consultation. Treatment differs from person to person — please discuss what is planned for you with your treating team. Appointments: (02) 9052 1883.

ACL injury & reconstruction

'A five-part guide to anterior cruciate ligament injury: what has torn, whether surgery is needed, the graft choices, the operation, and the nine-month road back to sport.'

A torn anterior cruciate ligament is the injury that ends seasons. It happens in a moment, usually without anyone touching you, and it raises the same questions in everyone: what exactly has torn, do I need an operation, which graft, how long until I can play, and will I get arthritis.

This guide answers those questions in order, across five chapters. It is written to be read at your own pace, before or after your consultation, and it is honest about the numbers, including the ones that are not reassuring: how many people get back to their sport, and how often the ACL tears again.

Three things are worth saying at the start.

First, **not every ACL tear needs surgery**. The randomised trials are clear that a rehabilitation-first approach, with reconstruction for the knees that stay unstable, gives similar results to early surgery for many people. The decision depends on your knee, your sport and what you want from it, and that conversation comes before any date is set.

Second, **the operation is the shorter part**. A reconstruction takes about an hour and is usually a day procedure. The recovery takes nine months to a year, and what you do in those months decides the result more than anything that happens in theatre.

Third, **the graft choice is made for you, not by habit**. Hamstring, patellar tendon, quadriceps tendon and donor tendon each have a track record, and the chapter on the operation sets out what the evidence shows about each, including the donor-tendon grafts this practice uses often.

Start with the first chapter below, or jump to the one that matches where you are.

SOURCES

- 1 'Ardern CL et al. Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta-analysis. Br J Sports Med 2014;48:1543–52' — <https://pubmed.ncbi.nlm.nih.gov/25157180/>
- 2 'Grindem H et al. Simple decision rules can reduce reinjury risk by 84% after ACL reconstruction: the Delaware-Oslo ACL cohort study. Br J Sports Med 2016;50:804–8' — <https://pubmed.ncbi.nlm.nih.gov/27162233/>

- 3 'Wiggins AJ et al. Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. Am J Sports Med 2016;44:1861–76' — <https://pubmed.ncbi.nlm.nih.gov/26772611/>
- 4 OrthoInfo (AAOS), Anterior Cruciate Ligament (ACL) Injuries — <https://orthoinfo.aaos.org/en/diseases--conditions/anterior-cruciate-ligament-acl-injuries/>

Understanding the injury

'What the anterior cruciate ligament does, how it tears, what else is usually damaged with it, and how the diagnosis is made: the examination first, the MRI second.'

The anterior cruciate ligament is a cord about the width of your little finger that runs diagonally through the centre of the knee. It is one of two cruciate ligaments, so called because they cross, and its job is stability: it stops the shin bone sliding forward under the thigh bone, and it stops the knee rotating too far when the foot is planted and the body turns. Walking, cycling and running in a straight line barely use it. Cutting, pivoting, landing and tackling depend on it.

How it tears

About three quarters of ACL tears happen without contact. The pattern is familiar to anyone who plays or watches pivoting sport: a sudden deceleration, a change of direction or a landing from a jump, with the knee nearly straight and collapsing inward while the body rotates over the planted foot. Most people feel or hear a pop, cannot continue, and have a knee that swells over the following hours as the joint fills with blood.

The rest are contact injuries, a blow to the outside of the knee in a tackle, which often damage the medial collateral ligament and the meniscus as well.

The numbers in Australia are high and rising. Between 2000 and 2015 the annual rate of ACL reconstruction rose by 43%, and by 74% in people under 25, with the fastest growth in children aged five to fourteen. In 2014-15 the peak was men aged 20 to 24 and women aged 15 to 19. In the same sports, female athletes tear the ligament at about three times the rate of male athletes per hour of play, which is why the warm-up programs covered in chapter 5 matter most for girls and women.

What else is damaged

An ACL tear is rarely an isolated injury, and what else is damaged often matters more for the long-term health of the knee than the ligament itself.

- **The meniscus.** The two menisci are the crescent-shaped cartilage cushions between the bones. In the Norwegian registry, 47% of knees coming to reconstruction had a meniscal tear. The lateral meniscus tears at the moment of injury; the medial meniscus tends to tear later, in a knee that keeps giving way. Whether a meniscal tear can be repaired rather than trimmed is one of the strongest predictors of arthritis decades on.

- **The joint surface.** About a quarter of knees have a cartilage injury at the time of surgery, and the proportion rises with delay and with each episode of instability.
- **Bone bruises.** The MRI almost always shows bruising in the bone on the outer side of the knee, where the bones collided as the knee gave way. In a large review, bruising was present on the outer shin bone in 83% of acute tears. It is the footprint of the injury, it is painful for some weeks, and it heals on its own.
- **The collateral ligaments.** The medial collateral ligament on the inner side of the knee is sprained in a proportion of tears, particularly contact ones, and usually heals in a brace without surgery.

How the diagnosis is made

The history is often diagnostic on its own: a non-contact twist, a pop, swelling within hours, and a knee that does not feel trustworthy afterwards.

The examination comes first. The Lachman test, done with the knee bent to about 20 degrees, detects about 85% of ACL tears and about 96% of complete ones, and it is almost never positive in an intact knee. The pivot-shift test reproduces the giving-way itself; it is positive in only about a quarter of tears in an awake patient, because the muscles guard against it, but when it is positive the diagnosis is certain. The examination is harder in the first week, when the knee is swollen and guarded, and is often repeated once the knee has settled.

The MRI confirms and surveys. MRI detects ACL tears with about 87% sensitivity and 93% specificity, so a small proportion of tears are missed and a small proportion of normal ligaments are over-called, which is why the examination matters. The more useful job of the MRI is the survey: the menisci, the cartilage, the collateral ligaments and the bone bruises, which together decide how urgent the next step is. X-rays are taken to exclude a fracture and, in a younger patient, to see how much growth is left.

Partial tears, and whether the ligament can heal

A complete tear does not reliably heal into a working ligament. The torn ends retract and bathe in joint fluid, and the scar that forms is rarely strong or tight enough to stop the knee giving way. Some partial tears, where enough of the ligament is intact, do settle and function. There is active research into early bracing of complete tears in a bent-knee position to bring the ends together, with healing visible on MRI in a large proportion; the next chapter covers what that evidence does and does not show.

What happens next

The first days are about settling the knee: ice, elevation, crutches while it is painful, and getting it straight. Within the first week or two the question becomes the one that matters, whether this knee needs a reconstruction, and that depends on the knee, the sport and the person. That is chapter 2.

SOURCES

- 1 'Zbrojkiewicz D, Vertullo C, Grayson JE. Increasing rates of anterior cruciate ligament reconstruction in young Australians, 2000–2015. *Med J Aust* 2018;208:354–8' — <https://pubmed.ncbi.nlm.nih.gov/29669497/>
- 2 'Boden BP, Dean GS, Feagin JA, Garrett WE. Mechanisms of anterior cruciate ligament injury. *Orthopedics* 2000;23:573–8' — <https://pubmed.ncbi.nlm.nih.gov/10875418/>
- 3 'Schilaty ND et al. Incidence of second anterior cruciate ligament tears and identification of associated risk factors from 2001 to 2010 using a geographic database. *Orthop J Sports Med* 2017;5:2325967117724196' — <https://pubmed.ncbi.nlm.nih.gov/28840155/>
- 4 'Montalvo AM et al. Anterior cruciate ligament injury risk in sport: a systematic review and meta-analysis of injury incidence by sex and sport classification. *J Athl Train* 2019;54:472–82' — <https://pubmed.ncbi.nlm.nih.gov/31009238/>
- 5 'Benjaminse A, Gokeler A, van der Schans CP. Clinical diagnosis of an anterior cruciate ligament rupture: a meta-analysis. *J Orthop Sports Phys Ther* 2006;36:267–88' — <https://pubmed.ncbi.nlm.nih.gov/16715828/>
- 6 'Phelan N, Rowland P, Galvin R, O'Byrne JM. A systematic review and meta-analysis of the diagnostic accuracy of MRI for suspected ACL and meniscal tears of the knee. *Knee Surg Sports Traumatol Arthrosc* 2016;24:1525–39' — <https://pubmed.ncbi.nlm.nih.gov/26614425/>
- 7 'Granat LP, Bahr R, Lie SA, Engebretsen L. Timing of anterior cruciate ligament reconstructive surgery and risk of cartilage lesions and meniscal tears: a cohort study based on the Norwegian National Knee Ligament Registry. *Am J Sports Med* 2009;37:955–61' — <https://pubmed.ncbi.nlm.nih.gov/19251674/>
- 8 'Sohn S, AlShammari SM, Hwang BJ, Kim MS. Bone bruise patterns in anterior cruciate ligament injury: a systematic review. *Bioengineering* 2024;11:396' — <https://pubmed.ncbi.nlm.nih.gov/38671817/>

Surgery or rehabilitation?

'Not every torn ACL needs a reconstruction. What the randomised trials show about rehabilitation first, who ends up needing surgery anyway, who should not wait, and the honest position on cross-bracing.'

Twenty years ago the answer was simple: a torn ACL in an active person was reconstructed. The randomised trials since then have made the question more interesting and the answer more individual, and it is worth understanding what they showed before deciding anything.

What the trials found

KANON (Sweden, 2010 and 2013) randomised 121 young, active adults with an acute tear to early reconstruction with rehabilitation, or to rehabilitation with the option of a later reconstruction if the knee needed it. At two years the two groups had improved by exactly the same amount, and at five years there was no difference in knee scores, in arthritis on X-ray or in the number of meniscal operations. Half of the rehabilitation-first group had chosen a reconstruction by five years; the other half never needed one.

COMPARE (Netherlands, 2021) repeated the design in 167 patients. At two years the early-surgery group scored slightly higher on a knee questionnaire, by five points on a 100-point scale, which the authors judged below the threshold that a patient would notice. Half of the rehabilitation-first group had surgery during follow-up. There were more re-ruptures and more opposite-knee tears in the early-surgery group, four and three against two and one.

ACL SNNAP (United Kingdom, 2022) asked a different question: what about the person who has already waited, whose knee is still unstable months after the injury? In 316 such patients, surgery beat further rehabilitation clearly, by about eight points on the same scale, and 41% of those allocated to rehabilitation needed an operation within eighteen months anyway.

The Cochrane review summarises the acute-injury evidence as showing no difference in patient-reported outcome at two or five years between early surgery and rehabilitation first, on low-quality evidence. A meta-analysis of twelve studies found surgery lowered the risk of a later meniscal operation and gave a more stable knee on examination, with no difference in arthritis.

What that means in practice

Put together, the trials say three things. Rehabilitation first is a legitimate strategy for an acute tear, and roughly half of people who take it never need an operation. Those who do need one lose nothing by having it later, provided the knee has not been giving way in the meantime. And a knee that is still unstable months after the injury should have surgery rather than more exercises.

So the decision turns on who is likely to cope without the ligament, and who is not.

Likely to cope. In the Delaware-Oslo cohort, about 54% of patients who chose rehabilitation had a successful outcome at two years, and the predictors were older age, female sex, a good single-leg hop test and good function on a questionnaire at the start. Among patients classified as potential copers after a structured strength and control program, about three quarters succeeded without surgery. The person who walks, cycles, swims, runs in straight lines and skis carefully, and whose knee feels trustworthy after a good rehabilitation program, often does not need a reconstruction.

Unlikely to cope, and better reconstructed:

- A knee that gives way, in sport or in daily life, despite rehabilitation. Each episode risks the meniscus and the cartilage.
- The athlete returning to pivoting sport: netball, the football codes, basketball, soccer, skiing. The younger and the more competitive, the stronger the case.
- A repairable meniscal tear. Meniscal repairs heal better alongside a reconstruction than alone, and the meniscus is worth more to the knee's future than the ligament is.
- Instability that has already persisted for months, where the trial evidence favours surgery outright.

Why an unstable knee should not wait

An unstable knee damages itself slowly. In a meta-analysis of timing, reconstruction more than three months after injury roughly doubled the rate of medial meniscal tears found at surgery, and the rise in high-grade cartilage damage became predominant after twelve months. In a population study, patients treated without surgery had more than five times the rate of a later meniscal tear and about six times the rate of arthritis compared with those reconstructed early. These are the reasons a reconstruction is recommended promptly for the knee that keeps giving way, and the reasons it is not recommended at all for the knee that does not.

The first few weeks after injury are different. A reconstruction done on a hot, stiff, swollen knee is the recipe for a stiff knee afterwards, and the meta-analysis of trials shows no penalty for surgery within three weeks once the knee is quiet. Settling the knee first, with

full extension and a working quadriceps, is the start of the program whichever way the decision goes.

Cross-bracing: the honest position

A Sydney group published a method in 2023 in which the knee is locked at 90 degrees of bend in a brace for four weeks and then straightened in stages, to bring the torn ends together. In their first 80 patients, 90% showed healing on MRI at three months, and those with the best-healed ligaments mostly returned to their sport; 14% re-injured the ligament, and two patients developed a clot in the leg before clot prevention was added to the protocol. It is a genuine advance in understanding, and the authors themselves call for trials before it changes practice.

A second series, published in 2026, applied the protocol to 40 athletes aged 16 to 40 in pivoting sports and found 70% had recurrent instability and 62% had a medial meniscal tear at two years, far worse than the reconstructed comparison group. The originating group disputes the methods of that study. Where that leaves a patient today: cross-bracing is an option to discuss for the right knee in a person who is not returning to pivoting sport, is unproven in trials, carries a clot risk, and is not something this practice recommends for athletes who intend to pivot again.

How the decision is made here

Not on the day of the injury, and not by rule. The knee is settled first. Its stability is examined once the swelling has gone, the MRI is reviewed for the meniscus and cartilage, and the conversation is about your sport, your age, your work and what you want the knee to do for the next thirty years. Where the answer is rehabilitation, it is a structured program with a review, and the option of surgery stays open. Where the answer is reconstruction, the next chapter covers the weeks before it.

SOURCES

- 1 'Frobell RB, Roos EM, Roos HP, Ranstam J, Lohmander LS. A randomized trial of treatment for acute anterior cruciate ligament tears. N Engl J Med 2010;363:331–42 (KANON)' — <https://pubmed.ncbi.nlm.nih.gov/20660401/>
- 2 'Frobell RB et al. Treatment for acute anterior cruciate ligament tear: five year outcome of randomised trial. BMJ 2013;346:f232' — <https://pubmed.ncbi.nlm.nih.gov/23349407/>
- 3 'Reijman M et al. Early surgical reconstruction versus rehabilitation with elective delayed reconstruction for patients with anterior cruciate ligament rupture: COMPARE randomised controlled trial. BMJ 2021;372:n375' — <https://pubmed.ncbi.nlm.nih.gov/33687926/>

- 4 'Beard DJ et al. Rehabilitation versus surgical reconstruction for non-acute anterior cruciate ligament injury (ACL SNNAP): a pragmatic randomised controlled trial. *Lancet* 2022;400:605–15' — <https://pubmed.ncbi.nlm.nih.gov/35988569/>
- 5 'Monk AP et al. Surgical versus conservative interventions for treating anterior cruciate ligament injuries. *Cochrane Database Syst Rev* 2016;4:CD011166' — <https://pubmed.ncbi.nlm.nih.gov/27039329/>
- 6 'Grindem H, Wellsandt E, Failla M, Snyder-Mackler L, Risberg MA. Anterior cruciate ligament injury: who succeeds without reconstructive surgery? The Delaware-Oslo ACL cohort study. *Orthop J Sports Med* 2018;6:2325967118774255' — <https://pubmed.ncbi.nlm.nih.gov/29854860/>
- 7 'Thoma LM et al. Coper classification early after anterior cruciate ligament rupture changes with progressive neuromuscular and strength training and is associated with 2-year success. *Am J Sports Med* 2019;47:807–14' — <https://pubmed.ncbi.nlm.nih.gov/30790527/>
- 8 'Sanders TL et al. Is anterior cruciate ligament reconstruction effective in preventing secondary meniscal tears and osteoarthritis? *Am J Sports Med* 2016;44:1699–707' — <https://pubmed.ncbi.nlm.nih.gov/26957217/>
- 9 'Prodromidis AD et al. Timing of anterior cruciate ligament reconstruction and relationship with meniscal tears: a systematic review and meta-analysis. *Am J Sports Med* 2021;49:2551–62' — <https://pubmed.ncbi.nlm.nih.gov/33166481/>
- 10 'Prodromidis AD et al. Relationship between timing of anterior cruciate ligament reconstruction and chondral injuries: a systematic review and meta-analysis. *Am J Sports Med* 2022;50:3733–41' — <https://pubmed.ncbi.nlm.nih.gov/34523380/>
- 11 'Filbay SR et al. Healing of acute anterior cruciate ligament rupture on MRI and outcomes following non-surgical management with the Cross Bracing Protocol. *Br J Sports Med* 2023;57:1490–7' — <https://pubmed.ncbi.nlm.nih.gov/37316199/>
- 12 'Porter MD, Shadbolt B. The Cross Bracing Protocol for ACL rupture in pivoting-sport athletes: recurrent instability and medial meniscal tears at two years. *Clin J Sport Med* 2026' — <https://pubmed.ncbi.nlm.nih.gov/41622530/>
- 13 'Deabate L et al. Anterior cruciate ligament reconstruction within 3 weeks does not increase stiffness and complications compared with delayed reconstruction: a meta-analysis of randomized controlled trials. *Am J Sports Med* 2020;48:1263–72' — <https://pubmed.ncbi.nlm.nih.gov/31381374/>

Preparing for surgery

'What happens between deciding on an ACL reconstruction and the day of surgery: prehabilitation, why the knee must be straight and quiet first, timing, consent, costs, tests and what to bring.'

Once we have decided together that a reconstruction is the right step, the next few weeks are not a waiting room. What you do with them affects the result more than almost anything that happens in theatre.

First, a quiet knee

An ACL reconstruction is not an emergency, and operating on a hot, swollen, stiff knee is the classic recipe for a stiff knee afterwards. Before surgery the knee needs to meet four targets:

- **Fully straight.** Full extension, equal to the other side. This is the one that matters most and the one people neglect, because a slightly bent knee feels more comfortable.
- **Swelling down.** A quiet knee, not a puffy one.
- **Quadriceps working.** Able to lift the straight leg without a lag, and to tense the thigh muscle on command.
- **Walking normally.** No limp.

A physiotherapist takes you through this, usually over three to six weeks from the injury. In a comparison of two large groups of patients, those who had a structured program before surgery had meaningfully better knee function two years after it. The program is the same one you will use afterwards, so you learn it before the knee is sore.

Timing

Once the knee is quiet, timing is about your life: your season, your exams, your work, your travel. Weeks or a few months of delay in a knee that is not giving way do not harm the result. What does harm it is a knee that keeps giving way while you wait. Each episode of instability can tear the meniscus or bruise the cartilage, and those injuries are what decide the long-term health of the knee. If the knee is unstable in daily life, surgery should not wait long. If it is stable with the brace of a good quadriceps, there is time to choose the date well. Surgery or rehabilitation? covers how that decision is made.

Consent, understanding the operation

Dr Broadhead will go through the operation with you: which graft and why, whether the meniscus is likely to need repair, whether an additional lateral procedure is planned, the risks that matter, and what the first year asks of you. You will sign a consent form, but the point is that you can explain the operation and the recovery in your own words before you agree to it. Bring your questions written down. Bring a parent or partner if you like; for a teenager, a parent is part of the conversation.

Costs, in writing

You will receive a written quotation before the procedure, setting out any out-of-pocket expenses for the surgeon, assistant, anaesthetist and hospital. In a public hospital there is no out-of-pocket cost. If the injury happened at work or in organised sport, workers compensation or a sports insurer may cover it; tell the rooms early, because the approvals take time.

Tests before surgery

The MRI that made the diagnosis is usually all the imaging needed, together with X-rays. For a younger patient whose growth plates may still be open, an X-ray of the knee and sometimes of the hand is taken to judge how much growth is left, which changes the technique. Routine blood tests and a heart tracing are arranged only where your health needs them.

The anaesthetic

Almost all reconstructions are done under a general anaesthetic, with local anaesthetic placed in and around the knee at the end of the operation so that you wake comfortable. Some anaesthetists add a nerve block; where one is used, it is the kind that spares the thigh muscle, because a quadriceps that will not switch on is the one thing the first fortnight cannot afford. The anaesthetist assesses you before surgery, at a pre-admission clinic or by phone.

What you can do yourself

- **Do the prehabilitation.** Every session.
- **Sort the logistics.** You will be on crutches for a week or two, you will not drive a right-knee reconstruction for four to six weeks, and you will need lifts to physiotherapy. Arrange them now.
- **If you smoke, stop.** Smoking impairs graft healing and wound healing.

- **Deal with infections early.** A skin wound, an ingrown toenail, a bad tooth or a bladder infection near the time of surgery can seed infection in the knee. See your GP about any of these.
- **Medicines.** Anti-inflammatories are usually stopped in the week before surgery; the oral contraceptive pill is a small clot risk and is discussed with the anaesthetist; supplements are stopped two weeks before. You will be told exactly what to do with each medicine.

The day itself

Most isolated reconstructions are done as a day case or with one night in hospital. The hospital will contact you the day before with an arrival time and fasting instructions; follow them exactly. Bring your medicines or a list, your crutches if you already have them, loose shorts or trousers that go over a bandaged knee, and your health fund or Medicare details. You will walk out on the leg, on crutches, with a written program, ice at home, and a physiotherapy appointment already made for the first week.

SOURCES

- 1 'Failla MJ et al. Does extended preoperative rehabilitation influence outcomes 2 years after ACL reconstruction? A comparative effectiveness study between the MOON and Delaware-Oslo ACL cohorts. *Am J Sports Med* 2016;44:2608–14' — <https://pubmed.ncbi.nlm.nih.gov/27416993/>
- 2 'van Melick N et al. Evidence-based clinical practice update: practice guidelines for anterior cruciate ligament rehabilitation based on a systematic review and multidisciplinary consensus. *Br J Sports Med* 2016;50:1506–15' — <https://pubmed.ncbi.nlm.nih.gov/27539507/>

The operation

'What an ACL reconstruction involves: the graft choices, including the donor tendon grafts this practice uses often, how the graft is placed and fixed, meniscal repair, the lateral tenodesis, and the risks.'

An ACL reconstruction does not repair the torn ligament. It replaces it with a tendon graft that the body then turns into a new ligament over the following year. The operation is done through keyhole portals, takes about an hour, and is usually a day procedure. What differs between surgeons and between patients is the graft, what is done to the meniscus, and whether anything is added on the outside of the knee.

The graft

Four grafts are in common use, and each has a long track record.

Hamstring tendons (your own semitendinosus, sometimes with gracilis), folded to make a four-strand cord. The commonest graft in Australia. Trade-offs: a weaker hamstring for the first year, an ache at the back of the thigh and a numb patch below the scar, and, in the Scandinavian registries, a higher revision rate than a patellar tendon graft, with a hazard ratio of about 2.3 in the Norwegian registry. The size of the tendon matters: a graft of 8 mm or less in diameter has carried about seven times the failure risk in pooled studies, and some people simply have small hamstrings.

Patellar tendon (bone-patellar tendon-bone, the central third of the tendon below the kneecap with a block of bone at each end). The most stable graft on examination, with bone-to-bone healing and the lowest revision rate in the registries. Trade-offs: more pain at the front of the knee, pain with kneeling in a proportion of patients that is the main reason people decline it, and a small loss of extension and of quadriceps strength in the Cochrane review.

Quadriceps tendon (a strip of the tendon above the kneecap). The newest of the three in common use. In meta-analyses it matches the patellar tendon for stability and failure with about a quarter of the donor-site pain, and it has failed less often than hamstring in young patients in recent pooled data. The thigh muscle is slower to switch on afterwards, and a Swedish registry has reported more re-operations for stiffness and pain, so the picture is still forming.

Donor tendon (allograft), a tendon from a tissue donor. No donor site, so no hamstring weakness, no kneeling pain, a shorter operation and an easier first few weeks. The trade-off is in how the tissue was prepared and in who receives it. Allografts that have been irradiated or chemically sterilised fail more often, and most of the data showing

allograft failing more are dominated by those grafts. In the largest registry analysis, non-processed donor tendons and those with minimal irradiation had no higher revision rate than hamstring autograft. In a systematic review of non-irradiated allograft against autograft, there was no difference in failure, laxity or knee scores, with the authors noting that this applied to patients in their late twenties and early thirties. In young, high-demand athletes the picture is different: a ten-year randomised trial in military patients with a median age of 26 found 26.5% failure with non-irradiated allograft against 8.3% with hamstring, and a large prospective cohort found about five times the re-tear odds with allograft, falling with each year of age.

In this practice a non-irradiated, non-chemically-processed donor tendon is the mainstay for most patients, including recreational athletes returning to pivoting sport, at any age. It avoids the small-hamstring problem altogether, it spares the front of the knee, and it is the graft of choice in revision and multi-ligament surgery. Professional and high-level competitive athletes typically have their own patellar tendon, because the high-demand cohorts are where allograft has failed more, and a lateral tenodesis is added where the knee warrants it. The distinction is the demand on the knee, not a birthday, and the numbers on both sides are part of the consent discussion. The full evidence, both sides of it, is on Which graft is best?.

How the graft is placed

Through two or three small portals, the inside of the knee is inspected and the menisci and cartilage are treated first. The remnants of the torn ligament are cleared, keeping the tissue at its attachments where that helps the graft heal. A tunnel is drilled in the femur and another in the tibia, each placed in the footprint where the original ligament attached, because tunnel position is what decides whether the graft controls rotation and lasts. The graft is pulled through, tensioned with the knee near full extension, and fixed at both ends, with a suspensory button or a screw depending on the graft. A single bundle is standard: the Cochrane review found no clinical difference between single- and double-bundle reconstruction.

The meniscus

Half of knees coming to reconstruction have a meniscal tear, and what is done about it matters more for the knee's long-term health than the ligament does. A tear in the vascular outer zone is repaired, with sutures passed through the meniscus, and a repair heals better alongside a reconstruction than on its own: in a population study, re-operation after repair was 9.7% with a concurrent reconstruction against 16.7% without. A tear that cannot be repaired is trimmed to a stable edge, removing as little as

possible, because meniscectomy is the strongest single predictor of arthritis after an ACL injury: 50% of patients with a meniscectomy had arthritis in one pooled analysis, against 16% of those without.

A meniscal repair changes the early rehabilitation: a hinged brace and protected weight bearing for four to six weeks, and no loaded deep bending for three to four months. The combined rehabilitation guide covers it.

The lateral extra-articular tenodesis

The ACL controls rotation as well as forward slide, and in some knees a graft inside the joint does not control rotation fully. A lateral extra-articular tenodesis is an additional step on the outside of the knee: a strip of the iliotibial band is routed beneath the lateral collateral ligament and fixed to the femur, acting as a rotational check-rein. In the STABILITY trial, 618 patients aged 14 to 25 having a hamstring reconstruction were randomised to have it or not. Over two years, graft rupture was 11% without it and 4% with it, and the broader measure of clinical failure fell from 40% to 25%. The cost was more pain in the first three to six months and a slightly larger scar. A Swedish registry found no difference in unselected patients at two years, which is why it is added selectively: the young athlete, the knee with a high-grade pivot shift, the revision, and the hyperlax knee.

Anaesthetic and the day

A general anaesthetic, with local anaesthetic placed in and around the knee at the end. Where a nerve block is added, it is an adductor canal block, which gives the same pain relief as the older femoral nerve block with better quadriceps strength in the first days, and a quadriceps that will not switch on is the one thing the first fortnight cannot afford. Most isolated reconstructions go home the same day; a reconstruction with a meniscal repair or a lateral procedure sometimes stays a night.

The risks, honestly

- **Infection.** About five in a thousand overall and about three in a thousand deep, in the largest registry, and higher with hamstring grafts than patellar tendon grafts (0.61% against 0.07% deep infection). An infection in a reconstructed knee is treated urgently with washout and antibiotics, and the graft can usually be saved.
- **Blood clots.** A symptomatic clot in about four in a thousand. Routine blood thinners are not used after an isolated reconstruction unless you have a particular risk factor; walking from day one is the prevention.

- **Stiffness.** A knee that loses its bend or, more importantly, its full extension. About 4% need a further procedure to free it, and the strongest risk factors are a knee that was stiff before surgery, a meniscal repair, and delayed rehabilitation afterwards, which is why the pre-operative program and the first fortnight matter so much.
- **Graft failure.** About 4% to 5% need a revision within five years across the registries. The figure is far higher in young athletes returning to pivoting sport, where graft rupture reached 18% at five years in an Australian cohort under 20, and it is the subject of chapter 5.
- **Numbness.** A patch of numb skin on the front of the shin below the scar after a hamstring graft is the rule rather than the exception; it shrinks over a year and rarely matters.
- **Donor-site problems.** Kneeling pain after a patellar tendon graft; hamstring weakness and a back-of-thigh ache after a hamstring graft; slower quadriceps recovery after a quadriceps tendon graft.
- **In a growing child,** disturbance of the growth plate, in about 2% to 5% of cases with modern techniques and almost always minor. See ACL injury in children and teenagers.

Your own risk profile, your age, your sport, your weight, diabetes and smoking, is part of the consent discussion. The surgeon's job is to reduce every risk that can be reduced and to be honest about the ones that cannot.

SOURCES

- 1 'Persson A et al. Increased risk of revision with hamstring tendon grafts compared with patellar tendon grafts after anterior cruciate ligament reconstruction: a study of 12,643 patients from the Norwegian Cruciate Ligament Registry, 2004–2012. *Am J Sports Med* 2014;42:285–91' — <https://pubmed.ncbi.nlm.nih.gov/24322979/>
- 2 'Mohtadi NG, Chan DS, Dainty KN, Whelan DB. Patellar tendon versus hamstring tendon autograft for anterior cruciate ligament rupture in adults. *Cochrane Database Syst Rev* 2011;9:CD005960' — <https://pubmed.ncbi.nlm.nih.gov/21901700/>
- 3 'Mouarbes D et al. Anterior cruciate ligament reconstruction: a systematic review and meta-analysis of outcomes for quadriceps tendon autograft versus bone-patellar tendon-bone and hamstring tendon autografts. *Am J Sports Med* 2019;47:3531–40' — <https://pubmed.ncbi.nlm.nih.gov/30790526/>
- 4 'Maletis GB, Chen J, Inacio MCS, Love RM, Funahashi TT. Increased risk of revision after anterior cruciate ligament reconstruction with soft tissue allografts compared with autografts: graft processing and time make a difference. *Am J Sports Med* 2017;45:1837–44' — <https://pubmed.ncbi.nlm.nih.gov/28301224/>
- 5 'Mariscalco MW et al. Autograft versus nonirradiated allograft tissue for anterior cruciate ligament reconstruction: a systematic review. *Am J Sports Med* 2014;42:492–9' — <https://pubmed.ncbi.nlm.nih.gov/23928319/>

- 6 'Bottoni CR et al. Autograft versus allograft anterior cruciate ligament reconstruction: a prospective, randomized clinical study with a minimum 10-year follow-up. *Am J Sports Med* 2015;43:2501–9' — <https://pubmed.ncbi.nlm.nih.gov/26311445/>
- 7 'Conte EJ, Hyatt AE, Gatt CJ, Dhawan A. Hamstring autograft size can be predicted and is a potential risk factor for anterior cruciate ligament reconstruction failure. *Arthroscopy* 2014;30:882–90' — <https://pubmed.ncbi.nlm.nih.gov/24951356/>
- 8 'Getgood AMJ et al. Lateral extra-articular tenodesis reduces failure of hamstring tendon autograft anterior cruciate ligament reconstruction: 2-year outcomes from the STABILITY study randomized clinical trial. *Am J Sports Med* 2020;48:285–97' — <https://pubmed.ncbi.nlm.nih.gov/31940222/>
- 9 'Wasserstein D et al. A matched-cohort population study of reoperation after meniscal repair with and without concomitant anterior cruciate ligament reconstruction. *Am J Sports Med* 2013;41:349–55' — <https://pubmed.ncbi.nlm.nih.gov/23263297/>
- 10 'Claes S, Hermie L, Verdonk R, Bellemans J, Verdonk P. Is osteoarthritis an inevitable consequence of anterior cruciate ligament reconstruction? A meta-analysis. *Knee Surg Sports Traumatol Arthrosc* 2013;21:1967–76' — <https://pubmed.ncbi.nlm.nih.gov/23100047/>
- 11 'Tiamklang T, Sumanont S, Foocharoen T, Laopaiboon M. Double-bundle versus single-bundle reconstruction for anterior cruciate ligament rupture in adults. *Cochrane Database Syst Rev* 2012;11:CD008413' — <https://pubmed.ncbi.nlm.nih.gov/23152258/>
- 12 'Yin X, Li X, Zhao P. Adductor canal block versus femoral nerve block after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *Medicine* 2022;101:e29295' — <https://pubmed.ncbi.nlm.nih.gov/35758360/>
- 13 'Maletis GB et al. Incidence of postoperative anterior cruciate ligament reconstruction infections: graft choice makes a difference. *Am J Sports Med* 2013;41:1780–5' — <https://pubmed.ncbi.nlm.nih.gov/23749343/>
- 14 'Das S et al. Symptomatic venous thromboembolism after anterior cruciate ligament reconstruction: a systematic review and meta-analysis of 29,186 patients. *J ISAKOS* 2026' — <https://pubmed.ncbi.nlm.nih.gov/41850529/>
- 15 'Federico AA, Qiu RY, Assadzadeh GE, Mohtadi NG. Loss of motion requiring surgery after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *J ISAKOS* 2026' — <https://pubmed.ncbi.nlm.nih.gov/41242397/>

Recovery and return to sport

'What recovery after ACL reconstruction really looks like, phase by phase: crutches for a week or two, running at about three months, pivoting sport not before nine, and the testing that decides it.'

Recovery after an ACL reconstruction is a long game, and it is better to know that at the start. The graft is strong enough for ordinary life quite quickly. A knee you can trust in a tackle, a cut or a landing takes nine months and more, and the reason is not caution for its own sake: the graft spends the first year turning back into a ligament, and the strength and control that protect it are built, not restored.

This chapter is the overview. The detailed week-by-week program, with the exercises, the dosages and the questions people ask at each stage, is in the ACL reconstruction rehabilitation guide. If your meniscus was repaired at the same time, the combined guide applies, and the early weeks are more protected.

The principle: dates are guides, tests are gates

Best practice after an ACL reconstruction is to progress by criteria, not by dates. Time sets the earliest possible point for each step. Measured criteria decide whether you actually move. Every phase below has an earliest date and a set of tests, and the tests win.

The first two weeks

Four jobs: a completely straight knee, minimal swelling, a quadriceps muscle that switches on and lifts the leg without a lag, and normal walking. Everything later depends on these four.

You can put full weight on the leg from the day of surgery, with crutches for balance, and most people are off them within one or two weeks. There is no routine brace after an isolated reconstruction: systematic reviews find bracing adds nothing to laxity, range, pain or function. Desk work is usually possible at one to two weeks. The wound is reviewed at about two weeks.

If you had a hamstring graft, the back of the thigh aches and a numb patch below the scar is common; heavy hamstring work waits four to six weeks. If you had a patellar tendon graft, the front of the knee is sorer and kneeling is a late milestone. If you had a quadriceps tendon graft, the thigh muscle is slower to switch on. If you had an allograft, there is no donor site to protect, but the graft itself matures more slowly, so the return-to-sport timeline is held to at least as firmly.

Weeks two to six

Walking normally, the bend returning, cycling on a stationary bike from about four weeks, and the first strength work: sit-to-stands, mini squats, heel raises, inner-range quadriceps. Swelling is the brake; a knee that is bigger the morning after is a knee that did too much. Driving a right-knee reconstruction is usually four to six weeks, when you are off strong painkillers and can emergency-stop without hesitation; a left knee in an automatic is often sooner. The clinical review with an X-ray is at six to eight weeks.

Six weeks to three months

Turning a settled knee into a strong one: progressively heavier gym work, leg press and squats, hip and hamstring strength, single-leg control and balance. Physical work returns in this window, usually six to twelve weeks depending on the job. The three-month review is the first gate: running is allowed from about three months if the knee is straight, dry, and the quadriceps is close to the other side.

Three to six months

Running progresses from straight lines to acceleration and deceleration. Strength work continues to build towards symmetry with the other leg. Plyometrics, landing mechanics and the first change-of-direction work start in the second half of this period, when the strength numbers allow. There is a six-month review.

Six to nine months

Sport-specific training: cutting, pivoting, sprinting, jumping and landing, and movement quality under fatigue, because the graft is most at risk when you are tired. Training with the team is possible; match play, including friendly games and social sport, is not. A friendly game asks the same of the graft as a real one.

Nine months: the test, then the return

At about nine months the knee is tested, not asked:

- **Strength:** quadriceps and hamstring strength compared with the other leg, with at least 90% symmetry the usual bar.
- **Hop tests:** single hop, triple hop, crossover hop and timed hop, each at 90% or better of the other leg.
- **Movement quality:** landing and cutting mechanics, including under fatigue.
- **Readiness:** a questionnaire on confidence and fear of re-injury, because fear of re-injury is the commonest reason athletes do not get back.

Two studies explain why this is done rather than skipped. In the Delaware-Oslo cohort, each month of waiting up to nine months cut the re-injury rate by about half, and athletes who went back before nine months re-injured far more often. In a separate cohort, athletes who returned without meeting six discharge criteria had about four times the graft rupture rate. Passing the test does not make the knee bulletproof; failing it and playing anyway is a known gamble.

How many people get back, and the risk of doing it again

Across studies, about 81% of people return to some sport after an ACL reconstruction, about 65% to their pre-injury level, and about 55% to competitive sport. The gap between the first and last figures is mostly fear of re-injury and changed priorities, not the knee.

The risk of another ACL injury is higher than most people expect, especially in the young. Across studies, about one in four athletes under 25 who return to sport sustain a further ACL injury to either knee, and the other knee is at least as vulnerable as the reconstructed one: about 8% contralateral against 7% on the operated side. In people reconstructed under 20, graft rupture alone was 18% at a mean of five years, highest in males under 18, and nearly half of those ruptures happened in the first year back. Three things lower the risk: the full nine months, passing the tests, and a structured warm-up program kept up through the season, which roughly halves the rate of ACL injury in the first place.

What is normal and what is not

Normal: a warm, slightly swollen knee for months; aching after a big day; a numb patch beside the scar; clicking as the muscles recover their control; the back of the thigh aching after a hamstring graft.

Not normal, and a same-day call: pain increasing after the first week, spreading redness or wound discharge, a temperature of 38°C or higher, a new one-sided calf pain or swelling (see your GP the same day), and chest pain or sudden shortness of breath (call 000). A knee that gives way, or a sudden pop with new swelling during the first year back, needs a review rather than a wait.

The follow-up

A wound review at about two weeks; a clinical review with an X-ray at six to eight weeks; reviews at three, six, nine and twelve months, with return-to-sport testing at the nine-month visit. The twelve-month review is where the result is judged.

SOURCES

- 1 'Grindem H et al. Simple decision rules can reduce reinjury risk by 84% after ACL reconstruction: the Delaware-Oslo ACL cohort study. *Br J Sports Med* 2016;50:804–8' — <https://pubmed.ncbi.nlm.nih.gov/27162233/>
- 2 'Kyritsis P et al. Likelihood of ACL graft rupture: not meeting six clinical discharge criteria before return to sport is associated with a four times greater risk of rupture. *Br J Sports Med* 2016;50:946–51' — <https://pubmed.ncbi.nlm.nih.gov/27215935/>
- 3 'Wiggins AJ et al. Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *Am J Sports Med* 2016;44:1861–76' — <https://pubmed.ncbi.nlm.nih.gov/26772611/>
- 4 'Webster KE, Feller JA. Exploring the high reinjury rate in younger patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med* 2016;44:2827–32' — <https://pubmed.ncbi.nlm.nih.gov/27390346/>
- 5 'Ardern CL et al. Fifty-five per cent return to competitive sport following anterior cruciate ligament reconstruction surgery: an updated systematic review and meta-analysis. *Br J Sports Med* 2014;48:1543–52' — <https://pubmed.ncbi.nlm.nih.gov/25157180/>
- 6 'van Melick N et al. Evidence-based clinical practice update: practice guidelines for anterior cruciate ligament rehabilitation based on a systematic review and multidisciplinary consensus. *Br J Sports Med* 2016;50:1506–15' — <https://pubmed.ncbi.nlm.nih.gov/27539507/>
- 7 'Kruse LM, Gray B, Wright RW. Rehabilitation after anterior cruciate ligament reconstruction: a systematic review. *J Bone Joint Surg Am* 2012;94:1737–48' — <https://pubmed.ncbi.nlm.nih.gov/23032584/>
- 8 'Wright RW, Fetzter GB. Bracing after ACL reconstruction: a systematic review. *Clin Orthop Relat Res* 2007;455:162–8' — <https://pubmed.ncbi.nlm.nih.gov/17279043/>
- 9 'Webster KE, Hewett TE. Meta-analysis of meta-analyses of anterior cruciate ligament injury reduction training programs. *J Orthop Res* 2018;36:2696–708' — <https://pubmed.ncbi.nlm.nih.gov/29737024/>

Which graft is best for ACL reconstruction?

'Hamstring, patellar tendon, quadriceps tendon or donor tendon: what the registries, trials and meta-analyses show about re-rupture, kneeling pain and strength, and why non-irradiated donor tendons are used in this practice.'

Every surgeon has a default graft, and every graft has a track record. This page sets out what the registries, the randomised trials and the meta-analyses show about each, including the donor-tendon grafts this practice uses often, with the evidence on both sides, so that the choice made for you is one you understand.

The four grafts in one table

Graft	Strength of evidence for durability	Donor-site cost	Best suited to
Hamstring (your own)	Good; about twice the revision risk of patellar tendon in registries; worse when the graft is 8 mm or less	Hamstring weakness for a year; back-of-thigh ache; numb patch on the shin	Most adults with adequate tendon size; people who kneel for work
Patellar tendon (your own)	Best in registries; most stable on examination	Front-of-knee pain; kneeling pain in a proportion; small loss of extension	Professional and high-level competitive athletes
Quadriceps tendon (your own)	Matches patellar tendon for failure in meta-analyses; newer, thinner data; a registry signal of more re-operation for stiffness	About a quarter of the patellar tendon's donor-site pain; slower quadriceps recovery	The high-level athlete who wants to avoid kneeling pain
Donor tendon, non-irradiated	Equal to hamstring in the largest registry and in meta-analyses of non-irradiated tissue; higher failure in young high-demand patients and with any irradiated or chemically processed tissue	None	Most patients at any age, including recreational athletes; small hamstrings; revision and multi-ligament surgery

Hamstring versus patellar tendon

The two grafts with the longest record. The Norwegian registry, 12,643 reconstructions, found a 5-year revision rate of 4.2% overall and a hazard ratio of 2.3 for hamstring against patellar tendon, highest in the youngest patients. The combined Scandinavian registries, 45,998 reconstructions, put the hazard ratio at 0.63 in favour of the patellar tendon, with the difference shrinking with age. In patients 25 and under, a 2026 meta-analysis of 46 studies found failure of 11.1% with hamstring against 5.1% with patellar tendon.

The Cochrane review explains the trade. Patellar tendon reconstructions were more stable on every test, and patients had more pain at the front of the knee and with

kneeling, a small loss of extension, and a trend to weaker quadriceps. The 2015 meta-analysis of 22 studies found no difference in laxity or failure, a better pivot-shift test and return to pre-injury activity with patellar tendon, and less anterior knee pain with hamstring.

Hamstring size

The hamstring graft's weakness is its variability. The tendon you were born with sets the graft's diameter, and diameter predicts failure. Across four studies, a graft of 8 mm or less carried a 6.8 times relative risk of failure. In one series, revision was 1.7% with grafts over 8 mm, 6.5% at 7.5 to 8 mm and 13.6% at 7 mm or less, and 14.3% in patients under 20 against 0.7% in those 20 and over. In the Kaiser registry, each extra half millimetre between 7 and 9 mm lowered the revision risk by 18%. Tendon size can be estimated before surgery from the MRI and from height and build, and a small predicted graft is one of the reasons the hamstring is not the default here: a donor tendon sidesteps the problem entirely, a patellar tendon does so for the high-level athlete, and a hamstring augmented with donor tissue, which in pooled data fails no more often than hamstring alone, is a third option.

Quadriceps tendon

In the 2019 meta-analysis of 27 studies, the quadriceps tendon matched the patellar tendon for laxity and failure with about a quarter of the donor-site pain, and matched hamstring for failure with slightly better knee scores. A 2024 meta-analysis found about half the failure risk of hamstring, and the 2026 pooled data in patients 25 and under put its failure at 2.5%. Against that, a Swedish registry of 5,653 cases reported a re-operation rate of 19.2% with quadriceps tendon against 8.9% with hamstring and 6.9% with patellar tendon, mostly for stiffness and pain, and the thigh muscle is slower to switch on afterwards. It is a good graft whose long-term picture is still forming.

Non-irradiated donor tendon: the evidence on both sides

A donor tendon, an allograft, is tendon from a tissue donor, screened, prepared and frozen by a tissue bank. It has no donor site: no hamstring to weaken, no patellar tendon to make kneeling painful, no second incision, a shorter operation and an easier first few weeks. The question has always been whether it lasts.

Processing is most of the answer. Allografts can be sterilised by irradiation or by chemical treatment, and both weaken the tissue. In the Kaiser Permanente registry's analysis of 5,968 allograft reconstructions, grafts irradiated above 1.8 Mrad carried 1.6 times the revision risk and chemically processed grafts 2.5 times, compared with other

preparation methods. In the same registry's comparison of 14,015 soft-tissue grafts, allografts irradiated at 1.8 Mrad or more carried 3.4 to 3.9 times the revision risk of hamstring autograft, and chemically processed grafts 3.0 times, while non-processed allografts and those with minimal irradiation were not found to have a different risk of revision from hamstring autografts. Much of the older evidence that allograft fails more often did not separate these, and is dominated by processed tissue.

For non-irradiated tissue in adults, the trials and meta-analyses find equivalence.

A 2013 review of eleven studies found no difference between autograft and non-irradiated, non-chemically-treated allograft in knee scores, laxity or failure. A 2014 systematic review of nine comparative studies found no difference in any outcome, with the explicit note that the findings applied to patients in their late twenties and early thirties. A 2016 meta-analysis of randomised trials found autograft better than allograft overall, but no difference on any of eight measures when the comparison was restricted to non-irradiated allograft. A 2018 meta-analysis of eleven trials and 1,172 patients reached the same conclusion: autograft better than irradiated allograft, no difference from non-irradiated. Individual randomised trials of fresh-frozen hamstring or tibialis allograft against hamstring autograft, in patients with mean ages around 30, found the same stability, the same knee scores and the same failure rates at two to eight years. A 2019 European consensus review put it plainly: similar low failure rates with non-irradiated, non-chemically-processed allograft and slower rehabilitation, but inferior results in young, highly active patients and with processed tissue.

For the young, high-demand athlete, the evidence goes the other way. A

randomised trial in 99 mostly active-duty military patients, median age 26, compared fresh-frozen, non-irradiated tibialis allograft with hamstring autograft and followed them for at least ten years: 26.5% of allografts and 8.3% of autografts failed. In the MOON prospective cohort of 2,488 reconstructions, the odds of re-tear were 5.2 times higher with allograft than with patellar tendon autograft, and fell with each year of age. In the Kaiser registry, revision risk fell by about a third with every five years of age among allograft recipients. A Sydney series of 144 sterilised allografts, median age 26, had 5% failure at two years, every one in a patient aged 25 or under. And bone-block patellar tendon allografts, as distinct from soft-tissue allografts, carried 4.5 times the revision risk of autograft in the Kaiser registry at every age and with every processing method. A 2026 meta-analysis of soft-tissue grafts found no difference in revision or re-tear between allograft and autograft, with a small advantage to autograft on two knee questionnaires.

How that evidence is applied here. Non-irradiated, non-chemically-processed soft-tissue donor tendon is the mainstay in this practice for most patients, at any age: the

recreational athlete returning to netball, football or skiing, the patient whose hamstrings measure small, the patient for whom kneeling pain from a patellar tendon graft would matter at work or in life, and revision and multi-ligament surgery where the patient's own tendons are already spent. Professional and high-level competitive athletes typically have their own patellar tendon, often with a lateral tenodesis, because the cohorts in which allograft failed more were high-demand ones: active-duty military and competitive athletes with high activity scores. The line is drawn at the demand on the knee rather than at an age. Allograft rehabilitation is deliberately no faster than autograft rehabilitation, because the graft matures more slowly. The choice is explained before the operation, with these numbers, and recorded in your consent.

What does not depend on the graft

Arthritis in the long term: a meta-analysis of randomised trials found no difference in post-traumatic arthritis between graft types. Return to sport: the graft changes the details of rehabilitation, not the timeline, and the nine-month rule and the return-to-sport testing apply to all of them. And the single biggest determinant of whether the new ligament survives is not the tissue it was made from but what is done in the year afterwards, which is chapter 5.

SOURCES

- 1 'Persson A et al. Increased risk of revision with hamstring tendon grafts compared with patellar tendon grafts: 12,643 patients from the Norwegian Cruciate Ligament Registry. *Am J Sports Med* 2014;42:285–91' — <https://pubmed.ncbi.nlm.nih.gov/24322979/>
- 2 'Gifstad T et al. Lower risk of revision with patellar tendon autografts compared with hamstring autografts: a registry study based on 45,998 primary ACL reconstructions in Scandinavia. *Am J Sports Med* 2014;42:2319–28' — <https://pubmed.ncbi.nlm.nih.gov/25201444/>
- 3 'Mohtadi NG, Chan DS, Dainty KN, Whelan DB. Patellar tendon versus hamstring tendon autograft for anterior cruciate ligament rupture in adults. *Cochrane Database Syst Rev* 2011;9:CD005960' — <https://pubmed.ncbi.nlm.nih.gov/21901700/>
- 4 'Xie X et al. A meta-analysis of bone-patellar tendon-bone autograft versus four-strand hamstring tendon autograft for anterior cruciate ligament reconstruction. *Knee* 2015;22:100–10' — <https://pubmed.ncbi.nlm.nih.gov/25547048/>
- 5 'Mouarbes D et al. Quadriceps tendon autograft versus bone-patellar tendon-bone and hamstring tendon autografts: a systematic review and meta-analysis. *Am J Sports Med* 2019;47:3531–40' — <https://pubmed.ncbi.nlm.nih.gov/30790526/>
- 6 'Petit CB et al. Graft failure by autograft type in patients 25 years and younger: a systematic review and meta-analysis of 10,624 patients. *Am J Sports Med* 2026' — <https://pubmed.ncbi.nlm.nih.gov/41733021/>

- 7 'Kekki C, Cristiani R, Stålmán A, von Essen C. Higher reoperation rate after quadriceps tendon autograft: 5,653 cases from the Swedish registry. *Am J Sports Med* 2026' — <https://pubmed.ncbi.nlm.nih.gov/42547948/>
- 8 'Conte EJ, Hyatt AE, Gatt CJ, Dhawan A. Hamstring autograft size can be predicted and is a potential risk factor for anterior cruciate ligament reconstruction failure. *Arthroscopy* 2014;30:882–90' — <https://pubmed.ncbi.nlm.nih.gov/24951356/>
- 9 'Magnussen RA et al. Graft size and patient age are predictors of early revision after anterior cruciate ligament reconstruction with hamstring autograft. *Arthroscopy* 2012;28:526–31' — <https://pubmed.ncbi.nlm.nih.gov/22305299/>
- 10 'Spragg L, Chen J, Mirzayan R, Love R, Maletis G. The effect of autologous hamstring graft diameter on the likelihood for revision of anterior cruciate ligament reconstruction. *Am J Sports Med* 2016;44:1475–81' — <https://pubmed.ncbi.nlm.nih.gov/27002103/>
- 11 'Lamblin CJ, Waterman BR, Lubowitz JH. Anterior cruciate ligament reconstruction with autografts compared with non-irradiated, non-chemically treated allografts. *Arthroscopy* 2013;29:1113–22' — <https://pubmed.ncbi.nlm.nih.gov/23522988/>
- 12 'Mariscalco MW et al. Autograft versus nonirradiated allograft tissue for anterior cruciate ligament reconstruction: a systematic review. *Am J Sports Med* 2014;42:492–9' — <https://pubmed.ncbi.nlm.nih.gov/23928319/>
- 13 'Zeng C et al. Autograft versus allograft in anterior cruciate ligament reconstruction: a meta-analysis of randomized controlled trials and systematic review of overlapping systematic reviews. *Arthroscopy* 2016;32:153–63' — <https://pubmed.ncbi.nlm.nih.gov/26474743/>
- 14 'Wang S, Zhang C, Cai Y, Lin X. Allograft versus autograft in anterior cruciate ligament reconstruction: a meta-analysis with trial sequential analysis. *Arthroscopy* 2018;34:3306–14' — <https://pubmed.ncbi.nlm.nih.gov/30396800/>
- 15 'Hulet C et al. The use of allograft tendons in primary ACL reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2019;27:1754–70' — <https://pubmed.ncbi.nlm.nih.gov/30830297/>
- 16 'Tejwani SG, Chen J, Funahashi TT, Love R, Maletis GB. Revision risk after allograft anterior cruciate ligament reconstruction: association with graft processing techniques, patient characteristics, and graft type. *Am J Sports Med* 2015;43:2696–705' — <https://pubmed.ncbi.nlm.nih.gov/26068037/>
- 17 'Maletis GB, Chen J, Inacio MCS, Love RM, Funahashi TT. Increased risk of revision after anterior cruciate ligament reconstruction with soft tissue allografts compared with autografts: graft processing and time make a difference. *Am J Sports Med* 2017;45:1837–44' — <https://pubmed.ncbi.nlm.nih.gov/28301224/>
- 18 'Maletis GB et al. Increased risk of revision after anterior cruciate ligament reconstruction with bone-patellar tendon-bone allografts compared with autografts. *Am J Sports Med* 2017;45:1333–40' — <https://pubmed.ncbi.nlm.nih.gov/28277740/>
- 19 'Bottoni CR et al. Autograft versus allograft anterior cruciate ligament reconstruction: a prospective, randomized clinical study with a minimum 10-year follow-up. *Am J Sports Med* 2015;43:2501–9' — <https://pubmed.ncbi.nlm.nih.gov/26311445/>

- 20'Sun K et al. Anterior cruciate ligament reconstruction with BPTB autograft, irradiated versus non-irradiated allograft, and hamstring autograft versus fresh-frozen allograft: prospective randomised studies. *Am J Sports Med* 2011;39:1430–8' — <https://pubmed.ncbi.nlm.nih.gov/21441418/>
- 21'Lawhorn KW et al. The effect of graft tissue on anterior cruciate ligament outcomes: a multicenter, prospective, randomized controlled trial comparing autograft hamstrings with fresh-frozen anterior tibialis allograft. *Arthroscopy* 2012;28:1079–86' — <https://pubmed.ncbi.nlm.nih.gov/22840988/>
- 22'Kaeding CC et al. Risk factors and predictors of subsequent ACL injury in either knee after ACL reconstruction: prospective analysis of 2,488 primary ACL reconstructions from the MOON cohort. *Am J Sports Med* 2015;43:1583–90' — <https://pubmed.ncbi.nlm.nih.gov/25899429/>
- 23'Gill SS et al. Medium-term functional outcomes comparing soft-tissue autografts with allografts in primary ACL reconstruction: a systematic review and meta-analysis. *Bone Jt Open* 2026' — <https://pubmed.ncbi.nlm.nih.gov/41784990/>
- 24'Farey JE, Salmon LJ, Roe JP, Russell V, Sundaraj K, Pinczewski LA. Outcomes of ACL reconstruction utilizing supercritical CO2-sterilized allografts. *Orthop J Sports Med* 2024;12:23259671241258489' — <https://pubmed.ncbi.nlm.nih.gov/39135859/>
- 25'Fan L et al. Hybrid graft versus autograft in anterior cruciate ligament reconstruction: a systematic review and meta-analysis of 1,411 patients. *J Orthop Surg Res* 2024;19:789' — <https://pubmed.ncbi.nlm.nih.gov/39609872/>

Will I get arthritis after an ACL injury?

'About four in ten knees show arthritis within fifteen years of an ACL injury, reconstructed or not. What actually drives that figure, why the meniscus matters more than the ligament, and what you can do about it.'

This is the question people ask quietly, usually some weeks after the injury, and it deserves a straight answer.

The figure

In a 2023 pooled analysis of studies with long follow-up, 37.9% of knees that had been reconstructed and 40.5% of knees treated without surgery showed arthritis on X-ray at a median of about fifteen years after the injury. Surgical technique has improved over the decades the studies covered, and the authors found that the year of surgery made little difference to the figure. For comparison, an uninjured knee in a person in their thirties or forties rarely shows arthritis at all.

Two things soften that number without removing it. Arthritis on an X-ray is not the same as a painful knee, and many knees with X-ray changes work well for decades. And "arthritis" in these studies ranges from minor narrowing to severe change; the proportion with the severe end is much smaller.

What the reconstruction does and does not do

The honest reading of the evidence is that reconstructing the ligament does not, by itself, prevent arthritis on the X-ray. The KANON trial found no difference in arthritis at five years between early reconstruction and rehabilitation first. A 2026 meta-analysis of 18 studies and 33,540 patients found no difference in X-ray arthritis between reconstructed and non-operated knees.

What the reconstruction does is protect the meniscus. The same meta-analysis found that reconstructed patients were much less likely to go on to a knee replacement, about one sixth the risk. A population study found that patients treated without surgery had more than five times the rate of a later meniscal tear and about six times the rate of arthritis compared with those reconstructed early. The ligament's job, in the long run, is to stop the knee giving way; each episode of giving way is a chance to tear the meniscus or damage the cartilage; and those are what drive the arthritis.

The meniscus is the thing

Across 1,554 reconstructed knees in a pooled analysis, 28% showed arthritis. Among those who had had part of a meniscus removed, it was 50%; among those who had not, 16%. The odds ratio for meniscectomy was 3.5, the largest single factor in the analysis. The MOON cohort's ten-year data point the same way: lateral meniscectomy and high-grade cartilage damage were among the strongest predictors of a worse knee at ten years, alongside smoking, higher body weight and a lower starting score.

This is why so much of the decision-making in this guide is about the meniscus rather than the ligament. A repairable tear is repaired, even though the recovery is slower. An unrepairable tear is trimmed as little as possible. And a knee that keeps giving way is reconstructed promptly, because each delay beyond three months roughly doubles the rate of medial meniscal tears found at surgery and, after twelve months, raises the rate of high-grade cartilage damage.

The graft does not change it

A meta-analysis of randomised trials found no difference in post-traumatic arthritis between graft types. Whether the new ligament came from your hamstring, your patellar tendon, your quadriceps tendon or a donor, the arthritis risk is set by the injury, the meniscus, the cartilage and what happens in the years afterwards.

What you can do

- **Do not play on an unstable knee.** The single most avoidable cause of meniscal and cartilage damage.
- **If the meniscus can be repaired, let it be.** The slower recovery buys decades.
- **Keep the quadriceps strong for life.** A strong thigh muscle unloads the joint; the program does not stop at nine months.
- **Keep your weight in a healthy range.** Higher body weight was an independent predictor of a worse knee at ten years in the MOON cohort, and it is the one factor entirely in your hands.
- **Do not smoke.** Smoking at the time of surgery predicted worse ten-year outcomes.
- **Keep up the warm-up program.** A second ACL injury to either knee doubles the problem, and structured programs halve the rate.
- **Be realistic about impact.** A knee that has had an ACL injury and a meniscal operation may not be a knee for high-impact sport into middle age. Cycling, swimming, rowing and the gym are kind to it.

If the knee does develop arthritis in later life, the options are the same as for any knee, and the hip and knee guide covers them, starting with the non-surgical ones.

SOURCES

- 1 'Liukkonen R, Vaajala M, Mattila VM, Reito A. Prevalence of post-traumatic osteoarthritis after anterior cruciate ligament injury remains high despite advances in surgical techniques. *Bone Joint J* 2023;105-B:1140–8' — <https://pubmed.ncbi.nlm.nih.gov/37907079/>
- 2 'Frobell RB et al. Treatment for acute anterior cruciate ligament tear: five year outcome of randomised trial. *BMJ* 2013;346:f232' — <https://pubmed.ncbi.nlm.nih.gov/23349407/>
- 3 'Blackman B et al. Anterior cruciate ligament reconstruction versus nonoperative management and the risk of osteoarthritis and total knee arthroplasty: a systematic review and meta-analysis of 33,540 patients. *Orthop J Sports Med* 2026' — <https://pubmed.ncbi.nlm.nih.gov/42539917/>
- 4 'Sanders TL et al. Is anterior cruciate ligament reconstruction effective in preventing secondary meniscal tears and osteoarthritis? *Am J Sports Med* 2016;44:1699–707' — <https://pubmed.ncbi.nlm.nih.gov/26957217/>
- 5 'Claes S, Hermie L, Verdonk R, Bellemans J, Verdonk P. Is osteoarthritis an inevitable consequence of anterior cruciate ligament reconstruction? A meta-analysis. *Knee Surg Sports Traumatol Arthrosc* 2013;21:1967–76' — <https://pubmed.ncbi.nlm.nih.gov/23100047/>
- 6 'MOON Knee Group. Ten-year outcomes and risk factors after anterior cruciate ligament reconstruction: a MOON longitudinal prospective cohort study. *Am J Sports Med* 2018;46:815–25' — <https://pubmed.ncbi.nlm.nih.gov/29543512/>
- 7 'Vendrig T et al. Graft type and post-traumatic osteoarthritis after anterior cruciate ligament reconstruction: a meta-analysis of randomised trials. *Orthop J Sports Med* 2024;12:23259671241255664' — <https://pubmed.ncbi.nlm.nih.gov/39157020/>
- 8 'Prodromidis AD et al. Relationship between timing of anterior cruciate ligament reconstruction and chondral injuries: a systematic review and meta-analysis. *Am J Sports Med* 2022;50:3733–41' — <https://pubmed.ncbi.nlm.nih.gov/34523380/>

ACL injury in children and teenagers

'Written for parents: why ACL tears in the growing knee are rising fast, how the growth plate shapes the operation, why the re-injury rate in the young is the highest of all, and the one rule that lowers it.'

An ACL tear in a child or a teenager is a different problem from the same tear in an adult, for three reasons: the knee is still growing, the years of sport ahead are many, and the re-injury rate in the young is the highest of any group. This page is written for parents, and it is honest about the last of those.

It is becoming more common

Between 2000 and 2015 the fastest growth in ACL reconstruction in Australia was in children aged five to fourteen, at about 8% a year, and paediatric reconstructions under Medicare rose steadily through 2020. The reasons are more organised sport, earlier specialisation in one sport, year-round seasons and better recognition of the injury. Girls aged 15 to 19 had the highest rate of reconstruction of any female age group.

The diagnosis

The same as in an adult: a non-contact twist or landing, a pop, swelling within hours, and a knee that does not feel right. The examination is the same and the MRI confirms it. Two differences matter. The ligament in a child can pull off with a flake of bone from the shin rather than tearing through its substance, which is a different injury with a different operation. And X-rays are taken to judge how much growth is left, which shapes everything that follows.

Surgery or not

The trials of rehabilitation-first treatment were done in adults, and the reasoning in children runs differently. A child or teenager who plays pivoting sport and has an unstable knee is at high risk of tearing the meniscus with each giving-way episode, the years of sport and of life ahead are long, and children are poor at avoiding the activities that make the knee give way. For that child, a reconstruction is usually recommended once the knee has settled. For the child who does not play pivoting sport and whose knee is stable in daily life, rehabilitation first with close review is reasonable. The decision is made with the family.

The growth plate

The growth plates at the lower end of the thigh bone and the upper end of the shin bone are where the tunnels for an adult reconstruction would go. Drilling across an open growth plate, or fixing a graft across it, can in principle disturb growth. The technique is therefore adapted to the child:

- **Several years of growth left:** tunnels and fixation placed entirely away from the growth plates, with the graft routed around them.
- **A year or two of growth left:** small, vertical tunnels crossing the plate, a soft-tissue graft with no bone block, and fixation kept well away from the plate.
- **Close to skeletal maturity:** an adult-style reconstruction.

Across the studies, a growth disturbance, a leg-length difference or an angulation, occurs in about 2% to 5% of cases and is almost always minor. In a 2010 pooled analysis of 55 studies it was 1.8%, and in a 2026 review of 579 children with techniques that avoid the femoral growth plate it was 4.5%, mostly minor overgrowth, with no child needing corrective surgery. The graft is a soft-tissue graft, usually the child's own hamstring or quadriceps tendon. Donor tendon is avoided in this group: in a registry of skeletally immature patients, revision was 13.2% with allograft against 7.5% with hamstring.

The number parents need to hear

The young athlete has the highest re-injury rate of any group having this operation. In an Australian cohort of 354 patients reconstructed under the age of 20, graft rupture occurred in 18% at an average of five years, and in 28% of boys under 18. Nearly half of the ruptures happened in the first year back. Adding injuries to the other knee, 35% had a further ACL injury. Across studies, about one in four athletes under 25 who return to sport sustain another ACL injury to either knee. Hamstring grafts in patients under 20 had a revision rate of 14% against under 1% in those 20 and over in one series, driven partly by small graft size.

Four things lower it, and none of them is optional in this practice:

- **The full nine months before pivoting sport.** Young athletes who returned to knee-strenuous sport before nine months had about seven times the rate of a second ACL injury. Half of adolescents are back in sport by eight months, and at that point only about three in ten have recovered their muscle function.
- **Passing a return-to-sport test.** Strength, hop tests, movement quality and readiness, at nine months, before any match play, including friendly games.
- **The right graft, and often a lateral tenodesis.** A patellar or quadriceps tendon graft rather than a small hamstring where growth allows, and a lateral extra-articular

tenodesis in the high-risk athlete: in a trial of 618 patients aged 14 to 25, it cut graft rupture from 11% to 4% over two years.

- **A structured warm-up program, every season.** Programs of landing, cutting and strength drills, done two or three times a week, halve the rate of ACL injury and reduce non-contact injuries in girls by two thirds. After a reconstruction the program is part of playing, for as long as they play.

For parents

The recovery is nine to twelve months, and the hardest part is the middle, when the knee feels normal and the season is on. The rule to hold is the nine-month rule, and the person who holds it is usually a parent. The ACL reconstruction rehabilitation guide has the week-by-week program; the recovery chapter explains why each step is where it is.

SOURCES

- 1 'Zbrojkiewicz D, Vertullo C, Grayson JE. Increasing rates of anterior cruciate ligament reconstruction in young Australians, 2000–2015. *Med J Aust* 2018;208:354–8' — <https://pubmed.ncbi.nlm.nih.gov/29669497/>
- 2 'Campbell RJ et al. Paediatric anterior cruciate ligament reconstruction in Australia, 2001 to 2020: Medicare Benefits Schedule data. *J Pediatr Orthop* 2024;44:e415–20' — <https://pubmed.ncbi.nlm.nih.gov/38444080/>
- 3 'Webster KE, Feller JA. Exploring the high reinjury rate in younger patients undergoing anterior cruciate ligament reconstruction. *Am J Sports Med* 2016;44:2827–32' — <https://pubmed.ncbi.nlm.nih.gov/27390346/>
- 4 'Wiggins AJ et al. Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction: a systematic review and meta-analysis. *Am J Sports Med* 2016;44:1861–76' — <https://pubmed.ncbi.nlm.nih.gov/26772611/>
- 5 'Magnussen RA et al. Graft size and patient age are predictors of early revision after anterior cruciate ligament reconstruction with hamstring autograft. *Arthroscopy* 2012;28:526–31' — <https://pubmed.ncbi.nlm.nih.gov/22305299/>
- 6 'Frosch KH et al. Outcomes and risks of operative treatment of rupture of the anterior cruciate ligament in children and adolescents. *Arthroscopy* 2010;26:1539–50' — <https://pubmed.ncbi.nlm.nih.gov/21035009/>
- 7 'Bini L et al. Growth disturbance and graft failure after femoral extra-physeal anterior cruciate ligament reconstruction in skeletally immature patients: a systematic review of 579 patients. *J Exp Orthop* 2026' — <https://pubmed.ncbi.nlm.nih.gov/42465677/>
- 8 'Nelson IR et al. A comparison of revision and rerupture rates of ACL reconstruction between autografts and allografts in the skeletally immature. *Knee Surg Sports Traumatol Arthrosc* 2016;24:773–9' — <https://pubmed.ncbi.nlm.nih.gov/26860097/>

- 9 'Getgood AMJ et al. Lateral extra-articular tenodesis reduces failure of hamstring tendon autograft anterior cruciate ligament reconstruction: 2-year outcomes from the STABILITY study randomized clinical trial. *Am J Sports Med* 2020;48:285–97' — <https://pubmed.ncbi.nlm.nih.gov/31940222/>
- 10 'Beischer S et al. Young athletes who return to sport before 9 months after anterior cruciate ligament reconstruction have a rate of new injury 7 times that of those who delay return. *J Orthop Sports Phys Ther* 2020;50:83–90' — <https://pubmed.ncbi.nlm.nih.gov/32005095/>
- 11 'Beischer S et al. Young athletes return too early to knee-strenuous sport, without acceptable knee function after anterior cruciate ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2018;26:1966–74' — <https://pubmed.ncbi.nlm.nih.gov/29032484/>
- 12 'Webster KE, Hewett TE. Meta-analysis of meta-analyses of anterior cruciate ligament injury reduction training programs. *J Orthop Res* 2018;36:2696–708' — <https://pubmed.ncbi.nlm.nih.gov/29737024/>