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Current concepts in graft selection for anterior cruciate ligament reconstruction

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- Graft selection for anterior cruciate ligament reconstruction (ACLR) is important for optimizing post-operative rehabilitation, facilitating return to full sporting function and reducing the risk of complications.
- The most commonly used grafts for ACLR include hamstring tendon autografts, bone–patellar tendon–bone autografts, quadriceps tendon autografts, allografts and synthetic grafts.
- This instructional review explores the existing literature on clinical outcomes with these different graft types for ACLR and provides an evidence-based approach for graft selection in ACLR.
- The existing evidence on the use of extra-articular tenodesis to provide additional rotational stability during ACLR is also revisited.

Keywords: ACL; anterior cruciate ligament; graft selection

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Introduction

Anterior cruciate ligament (ACL) injuries account for over half of all knee injuries sustained during sporting activity, with an estimated annual incidence of 30–78 injuries per 100,000 persons, with rising rates particularly in the adolescent population.[1–4] Patients with ACL injuries may complain of instability on return to sporting activity, and delays in treatment may lead to increased risk of meniscal tears, chondral injuries and early knee arthritis.[1,5–7] In symptomatic patients with moderate to high functional demands, ACL reconstruction (ACLR) is often recommended to enhance rehabilitation, facilitate early return to full sporting function and reduce the risk of long-term complications. The most commonly used grafts for ACLR include hamstring tendon (HT), bone–patellar tendon–bone (BPTB) and quadriceps tendon (QT) autografts, allografts and synthetic grafts. However, there is no uniform consensus on the single best graft choice for ACLR, with emerging evidence regarding the indications and outcomes for adjuvant surgical procedures to provide additional stability such as extra-articular tenodesis.

This instructional review explores the existing medical literature on clinical outcomes with these different graft types for ACLR and provides an evidence-based approach for optimal graft selection in ACLR. The existing evidence on the use of extra-articular tenodesis to provide additional rotational stability during ACLR is also revisited.

Hamstrings tendon autografts

Hamstring tendon autografts most commonly include the semitendinosus and/or gracilis tendons. These grafts have several key advantages that make them a popular choice for ACLR. Hamstring tendon autografts enable the patient's own tissue to be used, which minimizes the risk of graft infection, limits the local immune response and facilitates more rapid graft integration. These grafts are also harvested through smaller incisions and associated with lower risk of long-term anterior knee pain compared to BPTB grafts. The maximum load to failure in HT autografts is 4500 Newtons (N) compared to 2600 N in BPTB grafts. The main limitations of HT autografts are residual hamstring weakness, unpredictable graft size and saphenous nerve injury during harvest.[8] Importantly, these risks are often patient- and surgeon-dependent. Well-motivated and compliant patients often have minimal long-term hamstring weakness by increasing muscle strength in the biceps femoris and semimembranosus. High-volume

ACLR surgeons are able to harvest single or double hamstring grafts with minimal risk of iatrogenic nerve injury, and are able to compensate for small grafts by increasing the number of folds in graft preparation until a suitable diameter for the patient is achieved.[9] Overall, the evidence of HT autografts in ACLR shows a high return to preinjury level of sporting function, excellent functional outcomes and low risk of long-term complications.[8,10]

Bjornsson et al performed a prospective randomized controlled trial (RCT) of 193 patients undergoing ACLR with either BPTB (n = 61) autograft or HT (n = 86) autograft, with a mean age of 28.2 years and 26.8 years respectively.[11] At a mean follow-up of 16 years, there was no significant difference in knee stability between HT and BPTB autograft with respect to Lachman's test (P = 0.11) and pivot-shift test (P = 0.21). No difference was observed in graft rupture rate; BPTB: 6.6% (n = 4) and HT: 8.1% (n = 7) or the rate of contralateral ACL injury between the two groups; BPTB: 9.8% (n = 6) and HT: 7% (n = 6).[11] A statistically significant difference in favour of HT autograft was reported in assessment of the knee-walking test (P = 0.049) but no difference in all other clinical assessments. There was no significant difference in patient-reported function and outcomes between the two groups using the Tegner activity score (BPTB: 4.1 vs. HT: 4, P = 0.84); Lysholm knee score (BPTB: 79.4 vs. HT: 80.7, P = 0.77); and subjective International knee documentation committee (IKDC) score (HT: 67.3 vs. BPTB: 74.0, P = 0.05). Limitations of the study included the merging of two RCTs and 34% of all study patients were lost to follow-up. There were also variations in the harvest and preparation techniques within the HT group and BPTB autograft group.[11]

Chen et al performed a meta-analysis of nine RCTs with 630 patients undergoing ACLR with quadruple HT autografts (n = 317) versus BPTB autografts (n = 313) with minimum follow-up of five years.[12] The study found that patients undergoing HT autografts had reduced anterior knee pain compared to those undergoing BPTB autografts (P = 0.003). However, there was no significant difference in knee stability between the two groups as assessed using the KT-1000 score (P = 0.521), Lachman's test (P = 0.521), and pivot shift test (P = 0.07).[12] Further, patient-reported function scores including the Lysholm score (P = 0.094), IKDC score (P = 0.78) and Tegner score (P = 0.44) were comparable between the two groups. Clinical assessment found no significant difference in range of motion (P = 0.23), knee extension deficit > 5 degrees (P = 0.43), or single-legged hop test (P = 0.99) between the two groups.[12] Of the five studies that reported graft failure rates, there was no significant difference between BPTB and HT autografts (P = 0.14).

A meta-analysis of 23 RCTs compared the outcomes of 1986 patients undergoing primary ACLR with HT autograft (n = 993) or BPTB autograft (n = 993).[13] The patients had a mean age between 21.7 years and 38.0 years and were followed-up between 12 months to 17 years. There was a significant improvement in function within the HT autograft group at a medium-term follow-up (3–5 years) compared to BPTB autograft, objective IKDC score (P = 0.017). Over a short-term (< 2 years) and long-term (> 5 years) follow-up, anterior knee pain was found to be significantly reduced within the HT autograft group compared to the BPTB autograft group, P = 0.005 and P = 0.045 respectively.

Bone–patella tendon–bone autografts

Bone–patella tendon–bone autografts offer the same advantages of using the patient's own tissue as described for hamstring autografts above. BPTB grafts rely on bone-to-bone healing that may aid faster incorporation and enable more rigid fixation compared to HT grafts. Conceptually, BPTB grafts may also reduce the 'windshield wiper effect' associated with suspensory fixation, which may be associated with progressive tunnel abrasion and expansion with movement of the knee.[14] The main limitations of BPTB are anterior knee pain in up to 30% of patients, kneeling patella pain and increased risk of patella fracture and patella tendon rupture. Mismatch of BPTB graft and tunnel length may also lead to a small tibial bone plug and compromise the strength of the fixation.[15] Studies on BPTB autograft show excellent functional outcomes and return to sporting function but anterior knee pain remains the long-term drawback of this technique. The minimally invasive approach to BPTB graft harvest is reported to reduce the incidence of anterior knee pain; however, there is limited evidence within the current literature.[16]

A prospective RCT by Mohtadi et al compared the ACL quality-of-life (ACL-QOL) and clinical outcomes in 330 patients undergoing ACLR with either BPTB (n = 110), single-bundle HT (SBHT) autograft (n = 110), or double-bundle HT (DBHT) autografts (n = 110).[17] At five-years follow-up, a significantly lower number of traumatic graft ruptures were reported in the BPTB group (n = 4) compared to the DBHT group (n = 17) and SBHT group (n = 16) (p = 0.010). There was a higher percentage of kneeling pain amongst the BPTB group (10%), compared with SBHT (4%) and DBHT (2%) (P = 0.029).[17] There was no significant difference in the ACL-QOL outcome, pivot shift and single hop test between the BPTB and HS groups at five years follow-up.

A meta-analysis of 47,613 patients from 14 RCTs, 10 prospective cohort studies and one national registry study, compared graft failure rates in ACLR using HT autografts (n = 7,845) versus BPTB autografts (n = 39,768). At 68 months follow-up, the BPTB group were less likely to experience graft rupture or revision surgery compared to the HT group. The odds ratio for graft failure was 0.83

favouring the BPTB (95% confidence interval [CI], 0.72–0.96; P = 0.01) group.[18] There was no difference in knee stability as assessed using the KT1000 (p = 0.16), pivot shift test (p = 0.51) and Lachman's test (p = 0.84) between the two groups. However, this meta-analysis had several important limitations including pooling of data from studies using different surgical techniques, varying rehabilitation protocols, and limited follow-up times.

Quadriceps tendon autograft

In order to overcome the limitations of any residual hamstring weakness associated with HT autografts and anterior knee pain reported with BPTB autografts, some centres have recently used quadriceps tendon (QT) autografts. These may be performed using minimally invasive techniques for graft harvest and help reduce variation in graft sizes for ACLR. However, studies have shown conflicting results in knee stability, functional outcomes, donor site morbidity and survivorship of QT autografts compared to HT autografts and BPTB autografts.[19–22]

A systematic review of 1404 patients compared the outcomes of QT autografts ($n = 581$) versus BPTB ($n = 514$) and QT autograft ($n = 181$) versus HT autografts ($n = 176$) at a minimum of 12 months.[20] QT autografts were associated with reduced donor site pain compared to BPTB autografts ($P < 0.00001$) but no difference in graft survival between the two groups (P = 0.50). There was no difference in knee stability between the QT autograft and BPTB autograft groups as assessed using the side-to-side difference (SSD) (P = 0.45) or Lachman's test (P = 0.79). There was also no difference in functional outcomes, Lysholm score (P = 0.10), objective IKDC and subjective IKDC (P = 0.36) scores.[20] Comparing QT to HT autografts, there was a significant difference in patients' reported functional scores in favour of QT as assessed using the Lysholm score (QT: 157 vs. HT: 153, mean difference 3.81 [0.45–7.17], P = 0.03), but no difference in anterior knee pain (P = 0.40), graft rupture rate (P = 0.46) or Lachman's test (P = 0.41) between the two groups. The authors concluded that QT autografts were comparable to BPTB autografts and HT autografts in relation to knee stability, but QT autografts had less donor site pain compared to BPTB and better functional outcomes compared to HT autograft.[20]

Lind et al compared revision rates for ACL reconstructions performed using HT autografts versus QT grafts, using data from the Danish Knee Ligament Registry (DKLR).[21] In total, 16,579 ACL reconstructions suitable for the studies' inclusion and exclusion criteria were registered in the DKLR between 2005 and 2017. This included patients with QT autografts ($n = 531$); patients with HT autografts ($n = 14{,}213$); and patients with patella tendon (PT) autograft ($n = 1835$). Results revealed that QT autografts were associated with over double the number of revision rates (4.7%) compared to HT autografts (2.3%) at two years post-operative, with an adjusted hazard ratio of 1.74 ($p < 0.003$). The high revision rates for QT were markedly prominent in young patients aged 16–20 years, 10.3% revision rate compared to 3.8% in the HT group and 4.2% revision rate in the PT group within this age group. This is most likely due to the high return to contact pivoting sports in that age group. Additionally, 24% of the QT group displayed a positive pivot-shift test post-operatively, compared to 19% of the PT group and only 18% of the HT ($p < 0.05$), suggesting that the HT graft provided the most stable construct.[21]

Allograft

With no graft harvest site morbidity, no risk of residual hamstring weakness or anterior knee pain as seen with autografts, allograft has been a popular choice in the past, especially in the USA where athletes demand quicker return to sports. There is, however, a risk of graft disease transmission, increased time to incorporation and higher costs compared to HT and BPTB autografts. Allografts are prepared using deep freezing, radiation, chlorhexidine or supercritical carbon dioxide, with these processing techniques affecting the overall structural and mechanical properties of allografts to varying extents, with inferior outcomes reported in irradiated and chemically processed allografts.[23] The overall risk of ACLR re-rupture with allografts has been reported in some studies to be 3–4 times greater than for autografts, and therefore this option is often reserved for patients undergoing revision surgery or those with moderate to low functional demands.[24–26] The use of fresh frozen and non-irradiated allografts is reported to improve graft survival and therefore is a reasonable choice in this patient group.[27]

Kaeding et al, in a multicentre, prospective longitudinal cohort study (The MOON cohort) ($n = 2{,}683$), reported on risk factors for ACL failure following primary ACLR.[28] There was a 92.7% response rate at two years, with 4.4% ($n = 109$) patients reporting ipsilateral graft rupture and 3.5% ($n = 88$) of patients reporting a contralateral ACL tear. The use of allografts in primary ACLR was associated with a 5.2 times greater risk of graft rupture compared to BPTB autografts ($P < 0.01$), and patients under 30 years of age were associated with increased risk of re-rupture.[28] The study reported that by mid-30 years of age, there was no difference in graft rupture rate by graft choice. The authors reported that many allografts in the cohort had low-dose irradiation aimed at eliminating surface contaminants, whilst limiting the deleterious mechanical and structural effects of high-dose radiation on allografts. However, the effect of low-dose irradiation versus no irradiation on allografts is poorly studied; additionally, variables such as allograft donor demographics, anatomical origin of graft and the respective processing techniques were not controlled for, limiting the generalizability of findings to all allografts for ACLR.

A meta-analysis by Wang et al compared the clinical outcomes of 785 patients from eight RCTs undergoing primary ACLR with HT autografts (*n* = 396) versus soft-tissue allografts (*n* = 389).[29] At minimum two years follow-up, there was a significant difference in favour of HT autografts in patient-reported functional outcomes as assessed using the subjective IKDC score (P = 0.006) and Tegner score (P = 0.03) compared to soft-tissue allografts. There was no difference in knee stability and function between the two groups as reported using the pivot shift test (P = 0.24), anterior drawer test (P = 0.13), Lachman's test (P = 0.07), overall IKDC score (P = 0.57), and range of motion (P = 0.67). The two treatment groups had comparable complication rates, 26 vs. 25 events in the HT autograft and allograft groups respectively, of infection, graft failure and re-operation combined. The main limitations of this study were that the soft tissue allograft donor sites were not standardized, patients had different rehabilitation protocols, and follow-up times varied markedly between the studies included.[29] The meta-analysis also highlights that the average age of all studies is over 25 years old. We know from the literature that younger patients in high-demand sports are at most risk of re-rupture and therefore application of these findings for this group would not be appropriate.

Synthetic grafts

Over the last few decades, synthetic grafts have been developed to undertake direct ACLRs and indirect reinforcements of HT or BPTB autografts for ACLR. Conceptually, these synthetic materials provide tensile strength with a maximum load to failure force that exceeds that of the native ACL, whilst limiting the complications described with autografts and allografts described above. However, there is limited evidence on the strength of the synthetic grafts within the knee joint, synthetic debris may affect the function of the knee joint, promote synovitis and increase risk of revision surgery.[30] Preliminary studies using synthetic grafts for ACLR show promising results with early return to function and reduced donor site morbidity but are associated with higher failure rates compared to autografts. Revision of synthetic ACL reconstruction has the added challenges of widened bone tunnels, difficulty excising the graft and need for aggressive synovectomy due to particulate debris.[31]

The Ligament Augment Reconstruction System (LARS) (Surgical Implants and Devices, Arc-sur-Tille, France) is a synthetic ligament scaffold composed of polyethylene terephthalate fibres. Chen et al conducted a prospective cohort study in patients undergoing ACLR with HT autografts (*n* = 73) versus LARS (*n* = 38) with 10 years follow-up.[32] The study showed no significant difference in ACLR with HT autograft and LARS group with respect to the graft failure (failure rate: 8.2% vs. 7.9%, P = 0.910); mean SSD difference 2.4 mm versus 1.5 mm respectively (P = 0.131); and overall IKDC score 91.6 versus 89.8 (P = 0.124) respectively. Early subjective evaluation at six months showed improved outcomes in the LARS group compared to the HT autograft group with improved Lysholm score (88.1 ± 7.5 vs. 83.0 ± 7.8 respectively, P < 0.001); mean subjective IKDC score (86.9 ± 4.5 vs. 83.8 ± 7.8 respectively, P = 0.036); and mean Tegner score (5.0 ± 1.5 vs. 3.7 ± 1.1 respectively, P < 0.001). The authors attributed a lack of donor site morbidity in the LARS group to improved early functional outcomes in this group. Importantly, there was no difference in patient-reported outcome measures between the two groups at 10 years follow-up.

A meta-analysis by Batty et al presented data on the functional outcomes, complications and patient-reported outcomes of synthetic grafts in cruciate ligament reconstruction.[33] Thirteen studies reviewing the LARS graft use in 843 ACL reconstructions, of which 50 were revision ACL reconstructions, reported a 2.6% failure rate and 0.9% loss of flexion.[33] Twenty-six studies reported on the outcomes of the Kennedy ligament augmentation device (LAD) system in ACL reconstruction or augmentation in 1896 patients; at a range of 18 to 192 months follow-up, the graft failure rate was 13.2% and the non-infective synovitis rate was 4.7%. Twelve studies reporting on ACL reconstruction with the Leeds-Keio device followed 793 patients over a mean range of between 23 to 159 months; seven of these studies reported a failure rate of 16.8% of 356 grafts. Ten case series reporting on 525 knees with Dacron ligament for ACL reconstruction reported an overall 33.6% failure rate. The authors suggested that high failure rates of synthetic grafts with time could be due to a computation of mechanical failure and accumulation of synthetic wear debris in intra-articular structures.

Lateral extra-articular tenodesis (LET) to augment ACL reconstruction

The anterolateral structures (anterolateral ligament and iliotibial band) of the knee joint are important for providing rotational stability to the knee. In patients who have ACL tears with disruption to the anterolateral corner of the knee, ACLR alone may leave residual rotational instability and increase the risk of ACL re-rupture. In order to decrease failure rates following ACLR, patients with ligamentous laxity, hyperextension, strongly positive pivot shift test, and those in elite competitive pivoting sports, particularly at a younger age, may undergo ACLR with extra-articular tenodesis. The most commonly performed extra-articular augmentation procedures with ACLR include lateral extra-articular tenodesis (LET) and anterolateral ligament reconstruction (ALLR).[34] LET is reported to offload ACL graft by an average of 43%, reducing the risk of graft stretching or re-rupture during the rehabilitation phase.[35]

In young patients engaging in pivoting sports, ACL reconstruction with ALLR is reported to have a 2.5 times reduction in graft failure rate than BPTB autograft alone and 3.1 times reduction in graft failure rate compared to HT autograft alone, at a mean of 38 months follow-up.[36] Patients with ligamentous hyperlaxity undergoing ACL reconstruction with HT autograft and ALLR were found to have a lower graft failure rate and improved knee stability, compared to isolated HT autograft ACLR, 3.3% vs. 21.7%, at mean follow-up of 28.1 vs. 29.6 months respectively.[37]

Devitt et al conducted a meta-analysis exploring the effect of extra-articular tenodesis on functional outcomes in 738 patients from nine studies undergoing primary ACLR with LET at a minimum of two years follow-up.[38] Augmentation of ACLR with LET was associated with increased knee stability at a minimum of 2 years compared to ACLR alone; there was a 52% reduction in the risk of a positive pivot test post-operatively in the ACLR with LET group compared to the ACLR alone group (odds ratio: 0.48; 95% CI, 0.32–0.71; $P = 0.0003$). In patients who had ACLR with LET greater than 12 months after ACL rupture, there was a 44% lower incidence of a positive pivot test post-operatively compared to those undergoing ACLR alone ($P = 0.008$).[38] The main limitations of this study are the limited functional outcomes assessed and the pooling of data from studies using different surgical techniques and varying rehabilitation protocols, and the short-term follow-up of patients.

Getgood et al conducted a multicentre RCT in 589 high-risk patients with primary ACL ruptures undergoing ACLR with HT autografts ($n = 298$) versus HT autografts with LET using the modified Lemaire technique ($n = 291$).[39] Risk factors for graft failure were defined as participation in competitive pivoting sports, generalized laxity of ligaments, Grade-2 pivot shift or greater, or genu recurvatum > 10 degrees. Clinical failure (persistent rotational laxity at two years) was 40% ($n = 120$) in the ACLR group compared to 25% ($n = 72$) in the ACLR with LET group ($P < 0.001$). The graft rupture rate in the ACLR group was 11% ($n = 34$) compared to 4% ($n = 11$) in the ACLR with LET group ($P < 0.001$). There was a significant difference in early functional outcomes in favour of ACLR alone compared to ACLR with LET; as assessed pain score at three months after surgery ($P = 0.003$), IKDC score ($P = 0.03$) and knee injury osteoarthritis score (KOOS) score at six months after surgery ($P < 0.05$). However, no significant differences were reported in pain scores ($P = 0.7$), IKDC and KOOS scores between the two groups at two years after surgery ($P = 0.7$). Overall, ACLR with LET was found to provide clinically relevant reduction in graft failure and persistent rotational stability compared to ACLR alone within a high-risk group at two years follow-up.[39]

Registry data

Despite HT autografts being the most frequently used graft for ACLR, with the majority of soft tissue knee surgeons able to carry out this method, emerging trends suggest other graft types are gradually being employed. Geographically, European registries report HT autograft use in most ACLR (46.8–92.7%), followed by BPTB autografts (10.9–51.8%). This is in contrast to the Unites States of America, where allografts are used in 39.9% of ACLR followed by HT autografts at 32.6%.[40] Emerging evidence from large study data suggests that despite lower rates of ipsilateral ACL graft rupture in BPTB autograft ACLR, there is concern over an associated increase in contralateral ACL rupture (CACLR). A retrospective review of prospectively collected registry data of 7155 primary ACLR suggests an increased risk of contralateral ACL ligament rupture in patients receiving BPTB autograft (1.8%) compared to HT autografts (0.9%) $P = 0.04$.[41] However, revision rates in the HT autograft group were found to be significantly higher compared to BPTB autograft at a mean follow-up of 704 days (HT: 2.7% compared to BPTB: 1.3%, $P = 0.002$). Zhou et al in a meta-analysis reviewing 5561 primary ACLR, reported an increased risk of contralateral ACL ligament rupture in patients receiving BPTB autograft (8.5%) compared to HT autografts (3.3%) $p = 0.0004$.[42]

Discussion

HT autografts are associated with smaller incisions, reduced anterior knee pain, and greater maximum load to failure compared to BPTB grafts. BPTB grafts rely on bone-to-bone healing that has faster incorporation time and ability to rigidly fix the joint line, but there is a high incidence of anterior knee pain and increased risk of patella fracture. Allografts reduce harvest site morbidity but are associated with increased incorporation time and higher risk of rupture, and are therefore used primarily in revision surgery or in patients with low functional demands. Synthetic grafts in the short term are associated with comparable returns to sporting activity and functional performance to autografts but are reported to have a high graft failure rate in the long term. ACLR with lateral extra-articular tenodesis should be considered in younger and more high-demand patients with ACL rupture, particularly in the presence of concurrent anterolateral corner injuries, to minimize the risk of post-operative knee instability and to offload the ACL graft. When reviewing the literature and registry data we can see the most commonly used grafts in practice continue to be hamstring and BPTB autograft.

With little difference in re-rupture rates and outcomes the decision will usually come down to what technique and graft the surgeon is most familiar with. This ethos may have some merit when reviewing the Danish registry outcomes where Lind et al reported a high graft failure rate (6.4%) in ACLR with QT autograft by low volume ACLR centres (< 100 QT autograft ACLR) and comparable graft failure rates between QT autograft ACLR in high volume centres (> 100 ACLR) (2.9%), HT autograft (2.2%) and PT autograft (3.7%).[43] Surgeons should therefore maintain expertise in several techniques or refer patients to another specialist if the patient requests or needs an alternative graft choice.

The registry data highlight in the USA the increased use of allograft at 39% of all procedures and this significant proportion must be due to familiarity and ease of surgery, with less donor site morbidity and time saved.[40] Allograft tissue is more expensive, however, and will play a part in decision making for primary surgeries within the public healthcare systems when re-rupture rates are at best equivalent to those for autograft in the literature, and possibly inferior. Fresh frozen allograft seems to be the only preparation recommended and a potentially good choice for revision cases and older patients with less demand.

The literature does highlight that certain patient factors increase re-rupture rates independently of the graft choice. Younger patients in more high-demand sports are at high risk of re-rupture, and the trend in the literature suggests BPTB has reduced re-rupture rates but this is contentious. The promising technique of LET with hamstrings currently seems to have reduced re-rupture rates in this high-risk group. We will most likely see more of this procedure over the next few years and the long-term revision rates will guide us on future decision making.

Surgeons must treat patients on an individual basis and not rely on familiarity with one technique to make graft choice decisions. Being able to perform BPTB autograft or QT autograft for a sprinter who cannot lose hamstring strength for speed, whilst reverting to hamstrings graft for a sportsman or worker who kneels regularly will only improve outcomes. We may see improvements in synthetic technology potentially changing practice from autograft harvest but currently the data are not strong enough to drive this change.

Conclusion

ACLR remains the most commonly performed procedure in sports medicine, numerous patient and surgical factors contribute to selection of an ideal ACLR graft. Autografts offer a better graft survival, however, potential hamstring weakness might be a concern in athletes, and anterior knee pain and the risk of patella fracture are to be weighed with the use of BPTB autografts. Allografts are reported to be a risk factor for graft failure, particularly in young patients. However, this risk appears to be mitigated to some extent with the use of fresh frozen non-irradiated allografts, with frequent use in the USA.

Despite unacceptably high graft failure rates in synthetic grafts historically, there is a resurgence of its use in ACLR. Higher-quality studies with long-term follow-up are required to assess the outcomes of the new generation of synthetic grafts. Augmentation of ACLR with extra-articular tenodesis is an effective method of minimizing residual rotational instability observed in ACLR, which is independent of graft used; this is particularly useful in young, high-demand patients. The above factors, in conjunction with patients' age, activity level, and surgeon factors such as familiarity with a technique and graft type performed, should be considered when selecting the ideal ACL graft.

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