

Evaluating the functional results and complications of autograft vs allograft use for reconstruction of the anterior cruciate ligament: a systematic review

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Abstract

The aim of our review is to identify the reconstruction technique that has a superior functional outcome and decreased number of complications for the anterior cruciate ligament (ACL). We have divided our review into 2 sections. Our primary question evaluates the functional results and complications of autografts compared to allografts for ACL reconstruction. Our subsidiary question evaluates the functional results and complications of bone-patellar tendon-bone (BPTB) autografts compared to hamstring tendon autografts. We conducted a systematic review (SR) based on high quality evidence provided by Cochrane, PubMed and National Health Service evidence searches for papers comparing different ACL reconstruction techniques. Results from 2 primary studies, 1 SR and 1 meta-analysis showed no significant statistical difference when comparing clinical outcomes such as pain, range of motion, laxity, International Knee Documentation Committee score, single assessment numerical evaluation score, Tegner activity score and patient reported satisfaction with regards to autografts vs allografts. Allografts had worse outcomes for postoperative tibial tunnelling and graft failure. Results of 3 SRs showed statistically significant differences in incidence of anterior knee pain, kneeling pain and knee stability, which were all found to be greater amongst those who had received a BPTB autograft. Knee extension was significantly reduced in patients with BPTB grafts when compared to patients with Hamstring tendon autografts. However, with regards to return to prior levels of activity, there was no statistically significant difference between those that received BPTB autografts and those that received Hamstring

tendon autografts. Autograft reconstruction of the ACL was shown to provide better postoperative outcomes when compared to allograft reconstruction, although the difference was not statistically significant. When researching different autograft options BPTB autografts were associated with greater pain but also greater stability of the knee joint postoperatively when compared to hamstring tendon autografts.

Introduction

In sporting activities the knee is the most common joint to be injured and 40% of all knee injuries are due to ligament tears.¹ Within the knee the most commonly injured ligament is the anterior cruciate ligament (ACL) (49%).² In the United States of America the incidence of ACL tears is between 100,000 to 200,000.³ Women have been shown to have a higher incidence of ACL tears compared to men due to the anatomical and physiological differences between the sexes. Women have narrower cruciate ligaments and female sex hormones have physiological effects on ligaments.^{4,5}

ACL injury usually occurs during actions of decelerating, twisting, or jumping and is often accompanied by an audible *pop* sound. As mentioned previously they are common in sporting injuries but also in road traffic accidents. ACL tears, if left untreated, have poor healing potentially due to lack of a bridging scaffold that could bring the torn edges of the ligament together. Blood clots that could provide scaffolding and aid healing of the ligament cannot form within the synovial fluid of the knee joint.⁶

Untreated ACL tears can remain symptomatic with instability and associated knee pain. Secondary trauma can also occur from untreated ACL tears as surrounding structures overcompensate for the increased laxity causing meniscal tears and osteochondral injury. The combination of the sequelae of having an untreated ACL increases the incidence of developing osteoarthritis.⁷

ACL reconstruction is the gold standard for repairing ACL tears.⁸ Surgery to repair the ACL usually occurs 2-3 weeks after the injury to allow swelling to subside and physiotherapy sessions to take place to stabilize the knee before surgery.⁹ Two types of graft may be used for this surgery; an autograft or an allograft. An autograft is a *tissue graft taken from one part of the body and transferred to another part of the same individual*.¹⁰ An allograft is a *living tissue or organ graft between two members of the same species*.¹⁰ These both encompass dif-

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Contributions: all members of the group (OP, NK, NC and MB) met to identify a research question and to conduct the initial search for associated studies. NK researched and wrote the introduction to the paper. OP created flow diagrams of the literature searches. Our review was split into a primary question and subsidiary question. OP and NK reviewed and appraised the literature relating to the primary question and wrote the relevant section of the narrative review. NC and MB reviewed and appraised the literature relating to the subsidiary question and wrote that section of the narrative review. Gaps in the literature and suggestions for future research were identified by NC and MB. All members of the group (OP, NK, NC and MB) contributed to the discussion and conclusion sections. OP reviewed the references to ensure they were correct. LD formed the design of the systematic review, drafted the paper and analyzed it critically, and also approved the final version.

Key words: Autografts; Allografts; Anterior cruciate ligament; Reconstruction.

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ferent advantages and disadvantages. The importance of choosing the appropriate graft for best outcomes according to the patient's needs is paramount. For this reason, we will perform a review of current literature to determine the best type of graft to be used for ACL reconstruction.

Our aim is to critically appraise appropriate literature regarding ACL reconstruction to identify which type of graft yields the best results in regards to joint function and pain.

Materials and Methods

Our study has been performed in two parts. The first part aims to determine which type of graft between autograft and allograft

is superior. The second part aims to determine which autograft choice is superior; either the bone-patellar tendon-bone (BPTB) autograft or Hamstring tendon autograft. We defined *superior* with regards to functionality, return to activity, pain and graft failure rates.

Part 1: Primary question – autograft vs allograft

Our search began with looking at databases such as MEDLINE and the Cochrane database of systematic reviews (SRs). Constructing a population intervention comparator outcome (PICO) helped our search, as shown in Table 1. The studies were searched for and reviewed independently by two reviewers (NK, OP) and results were discussed together with any disagreements resolved by two other independent reviewers (MB, NC). We focused our search using the following keywords *Autograft*, *Allograft* and *Anterior Cruciate Ligament*. Inclusion and exclusion criteria for both Part 1 and Part 2 are shown in Table 2. SRs were searched for because they are at the top of the hierarchy of evidence in terms of reliability and validity. The appropriate Critical Appraisal Skills Programme (CASP) appraisal tool was used for all studies.¹¹

Part 2: Subsidiary question – hamstring autograft vs bone-patella tendon-bone autograft

We conducted a search of Medline, and the Cochrane Library exploring the terms *anterior cruciate ligament*, *autograft*, *bone-patellar tendon-bone graft*. We also conducted a search of NHS evidence using the search *ACL hamstring tendon patellar tendon*, where we identified a Cochrane SR. Our outcomes were those of our primary question. They were divided between clinical outcomes (stability, degree of movement and return to prior function) and patient reported outcomes (pain). We also eliminated one SR that focused on isokinetic muscle strength, as its primary outcome of muscle strength was not one of our primary outcomes.¹²

4.362 relative to other sports medicine and science journals which makes the journal reputable.¹³ The review compared outcomes between autograft tendons and non-irradiated Allograft tendons. It consisted of 9 studies that excluded non-English and non-published papers leading to language and publication biases. Of the 9 studies, only 3 were RCTs that are the most appropriate in answering their review question as we are comparing 2 interventions. Also, the mean age of participants is in the late 20s and early 30s, for this reason the results cannot be applied to a higher risk population such as young athletes. Grafts were harvested from different locations in the 9 studies, such as the BPTB, hamstring tendon and posterior tibialis tendon. This could be an important variable that can affect graft failure, postoperative laxity and patient-reported scores. For this reason in our subsidiary question we have addressed the differences in outcome for grafts harvested from the BPTB compared to the hamstring tendon.¹³

A study done by Bottini *et al.* in 2015 was a prospective randomized clinical study that involved treating patients with either a hamstring tendon autograft or a posterior tibialis allograft reconstruction.¹⁴ Patients were followed up until 10 years after initial procedure and outcomes were measured and compared. The primary outcomes measured were clearly stated as graft survivorship and subjective functional knee stability. It aimed to evaluate the differences in these outcomes between autograft and allograft anterior cruciate ligament recon-

struction in active individuals (95% of patients were active duty military). In depth appraisal using the appropriate CASP checklist tool can be found in the Appendix for all studies included in this paper.¹¹

Another study by Jia *et al.* in 2015 found similar results to the Bottini *et al.* study when comparing clinical outcomes between hamstring tendon autografts and bone-patellar tendon-bone allografts. This study randomized 106 patients into two groups (53 in each) to receive reconstruction with either an autograft or an allograft. The study population was defined as patients with ACL tears confirmed by clinical examination and MRI. Outcome measures of the study included IKDC, Lysholm scores, physical instability tests and tibial and femoral tunnel widening.¹⁵

Graft failure

The primary study by Jia *et al.* in 2015 with 106 patients had no cases of graft failure in either the autograft or the allograft groups.¹⁵ The other RCT by Bottini *et al.* showed that allograft reconstructions showed a 26.5% failure rate as compared to 8.3% failure in autograft reconstructions in the index operation.¹⁴ These differences were found to be statistically significant ($P=0.031$). However when considering the Mariscalco *et al.* the clinical failure risk showed no statistical difference in risk between autograft and allograft, (RR 0.75, 95% CI 0.25-2.24, $P>0.05$).¹³

Objective clinical tests

The trial by Bottini *et al.* did not consid-

Table 1. Population, intervention, comparator, and outcome of autograft vs allograft use for anterior cruciate ligament reconstruction.

Population	Adult patients (above the age of 18) with torn ACL (excluding congenital malformation of ACL)
Intervention	Autograft
Comparator	Allograft
Outcomes	Graft failure rates, functional outcomes (e.g. stability, ROM, IKDC score, Lysholm Tegner score, laxity, SANE score) and patient reported outcomes (e.g. self-reported patient satisfaction and postoperative pain)

ACL, anterior cruciate ligament; ROM, range of motion; IKDC, International Knee Documentation Committee; SANE, single assessment numerical evaluation.

Results and Discussion

Part 1: Autograft vs allograft

Our search strategy for Part 1 seen in Figure 1 identified 1 SR and 2 randomized controlled trials (RCTs). The study characteristics are highlighted in Table 2. The first review by Mariscalco *et al.* in 2013 is published in the American Journal of Sports Medicine which has a high impact factor of

Table 2. Characteristics of studies used in critical appraisal.

Criteria of inclusion	Criteria of exclusion
Study design: SR or RCT	Language (non-English)
Availability of full text	Non-human studies
Adult participants	Studies including children in cohort
Studies published after 1945	

SR, systematic review; RCT, randomized controlled trials..

er any objective clinical tests.¹⁴ The trial by Jia *et al.* and the SR both measured anterior laxity using the Lachman's test and rotational laxity using the pivot-shift test. The study by Jia *et al.* showed no significant differences between the autograft and allograft groups in post-operative Lachman's scores and pivot-shift scores ($P=0.5$, $P=0.5$).¹⁵ The results from the SR were consistent with these findings.¹³ No statistical differences were seen in Lachman's scores (RR 1.11, 95% CI 0.79-1.57, $P>0.05$) or pivot-shift tests (RR 1.06, 95% CI 0.66-1.70, $P>0.05$) between the two groups.

Subjective clinical outcomes

For the patient-reported scores all studies utilised the Lysholm Tegner and IKDC scores. These are scores based on questionnaires filled in by patients regarding knee stability, activity levels and pain among other outcomes. The study by Bottini *et al.* (2015) showed no statistically significant differences in either the Lysholm Tegner score ($P=0.935$) or the IKDC score ($P=0.773$) between autograft and allograft groups at 10 years postoperatively.¹⁴ The other primary study by Jia *et al.* (2015) also had similar results showing no statistical differences between these scores; Lysholm Tegner score ($P>0.5$), IKDC score ($P>0.5$).¹⁵ Finally the SR also looked at differences between autograft and allograft groups in regards to these outcomes and again the results showed no statistically significant difference.¹³

Tibial and femoral tunnel widening

The study by Bottini *et al.* looked at the mean tibial and femoral tunnel size 10 years post operatively in the autograft and allograft groups.¹⁴ The autograft group had a mean tibial tunnel size of 8.8 mm (range: 7.0-10.0 mm) as compared to the allograft group where the mean tunnel size was 9.0 mm (range: 7.0-10.0 mm). This difference was not statistically significant ($P=0.651$). The mean femoral tunnel size measured at 10 years in the autograft group was 8.3 mm (range: 7.0-10.0 mm) as compared to the allograft group that had a mean tunnel size of 8.5 mm (range: 7.0-10.0 mm). This difference too was statistically insignificant ($P=0.453$).

The study by Jia *et al.* looked at the difference in femoral and tibial tunnel widening postoperatively and at follow up (mean follow up=81 months). Autografts showed lower tibial and femoral tunnel widening at follow up when compared to allografts. These results were statistically significant for both tibial and femoral widening measurements ($P=0.001$ and $P=0.03$, respectively). The effect was greater on tibial tunnel widening.¹⁵

Part 2: Subsidiary question – patellar tendon vs hamstring tendon

Having compared autograft vs allograft use, we identified a subsidiary question to determine which form of autograft tendon may be superior. Commonly used tendon grafts are patellar and hamstring.¹⁶ Our subsidiary question aims to compare outcomes of these two grafts.

Our search identified three SRs as seen in Figure 2. The first, a Cochrane SR published in 2011, compared outcomes with use of patellar tendons and hamstring tendons during autograft ACL reconstruction. It included 1597 participants from 19 studies. The review showed that at least 10 of the 19 studies were at high risk of bias in multiple areas; selection, performance, detection, attrition and reporting bias.¹⁶ Additionally none of the studies were conducted in or included participants from the United Kingdom, however all studies were conducted in developed countries so the results are still likely to be applicable to the local population.

The second review by Li *et al.* published in 2010 included 19 RCTs with a total of 1643 participants.¹⁷ The Jadad composite quality scores of the studies included in this review however, were all quite low suggesting that the studies included may not have used appropriate randomization possibly leading to selection bias or they may not have incorporated appropriate blinding of

assessors possibly resulting in allocation or performance bias.

The third review by Magnussen *et al.* (2011), analyzed outcomes after a minimum of 5 years post ACL reconstruction surgery.¹⁸ Seven studies were included within this review. Five were RCTs whilst the remaining 2 were cohort studies where there was the potential for selection bias as participants were not randomized into trial arms. Many different tests were used in studies to report outcomes. To outline these; Tegner and Lysholm scores evaluate return to previous levels of activity. Lachman, pivot-shift and KT-1000 tests are measures of stability.

Return to activity

A meta-analysis of four studies within the Cochrane review reported no statistically significant difference in return to previous function between the two groups, measured by return to light or sedentary activity. Data from four studies reporting on the Tegner score also reported no statistically significant difference (mean difference 0.23, 95% CI -0.12 to 0.59). Five other trials that could not be pooled but also commented on Tegner scores again found no statistically significant difference between groups. There was also no statistically significant difference in the Lysholm score between groups in a meta-analysis of five trials (mean difference 0.00, 95% CI -1.72 to 1.72). Whilst four other studies independ-

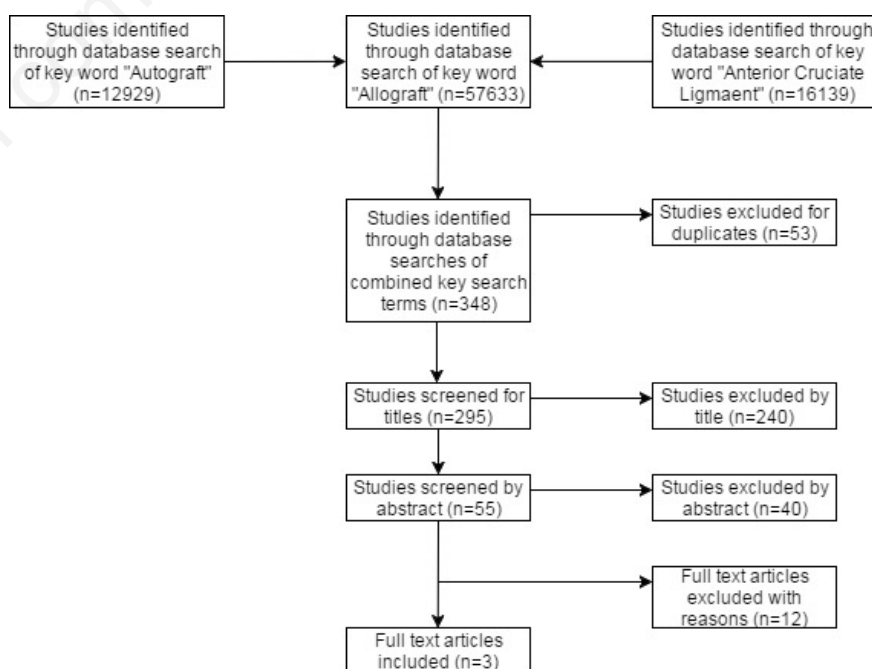


Figure 1. Flow diagram of the literature search comparing autograft to allograft anterior cruciate ligament reconstruction.

ently reached the same conclusion, one study alone reported a statistically significant difference between patellar and hamstring tendon use, stating that two-incision patellar tendon reconstruction led to return to a higher level of activity. However, given that only one study reported this outcome, and it was among the studies identified as having a high risk of bias, we believe that there is sufficient evidence to suggest that there is no statistically significant difference in return to previous activity when comparing patellar-tendon and hamstring-tendon use.¹⁶

Stability

Pooled data from the majority of studies within the Cochrane review that used Lachman testing to determine static stability showed a statistically significant difference favouring patellar tendon use (RR 0.83, 95% CI 0.71 to 0.99).¹⁶

Pivot-shift testing also showed increased stability with patellar tendon use. A meta-analysis of 14 studies reported a statistically significant difference in favour of patellar tendon use with a 30 percent decrease in positive test outcomes.¹⁶

Li *et al.*'s 2010 SR also assessed the stability of the knee joint after Hamstring tendon or BPTB autografts.¹⁷ There was some confusion over the results for this outcome as forest plot graphs included for the Lachman test and pivot-shift showed summary statistics favouring Hamstring Tendon autografts but within the text of the study it claimed that the meta-analysis results of favoured BPTB autografts.¹⁷ Fortunately they also included the raw data so we were able to assess the results of both these tests ourselves. We calculated that BPTB autografts were associated with greater stability although since the confidence intervals included the null value these results were not deemed to be statistically significant.¹⁷ For KT-1000 testing, however, the difference in mean scores was deemed to be statistically significant.¹⁷ The results suggested that BPTB autografts provide more knee stability than the hamstring autograft alternatives which is in agreement with the results of the previous review.

However, Magnussen *et al.* (2011) review did not identify any significant difference in knee stability between Hamstring and BPTB autografts in any included studies.¹⁸

Despite this given the two previous positive results and that the Cochrane review was conducted to a very high standard, we suggest that there is increased stability with BPTB autograft use when compared to hamstring tendons.

Range of motion

Regarding degree of motion, a meta-analysis of 14 studies within the Cochrane review analysing extension deficit reported a statistically significant difference in which hamstring tendon was associated with less post-procedural deficit (RR 1.71 95% CI 1.25 to 2.33).¹⁶ Li *et al.* (2010) also reported significantly greater extension loss in patients who had a BPTB autografts (RR=0.49, 95% CI 0.33-0.74) when compared to Hamstring tendon grafts.¹⁷ Contrastingly, pooled data from 12 studies within the Cochrane review regarding deficits in flexion reported a more favorable outcome with patellar tendon use, however this was not statistically significant.¹⁶ Due to these contrasting results it was not possible to conclude whether ROM is affected more by one autograft type than by the other.

Pain

Post-procedural pain was reported as an outcome in all of the SRs we identified in our search. The results from the studies included in the Cochrane review were pooled as anterior knee symptoms and discomfort kneeling. The presence of anterior knee symptoms and kneeling pain were both greater with patellar tendon use and this difference was statistically significant with a 45% increase (95% CI 1.05-2.01)

and 346% increase (95% CI 2.97-6.69) respectively.¹⁶ These results were mirrored in Li *et al.*'s (2010) review. They identified that the relative risk summary statistic of developing anterior knee pain with a hamstring graft when compared with a BPTB graft was 0.58 which suggests that patients with a hamstring tendon autograft are 42% less likely to develop postoperative anterior knee pain than patients with BPTB autografts. For kneeling pain the relative risk summary statistic was recorded as 0.27 suggesting that patients with hamstring tendon grafts were 73% less likely to experience anterior kneeling pain when compared to patients receiving BPTB autografts. The confidence intervals for both these outcome measurements were narrow and they did not cross the null value showing that the results were precise as well as statistically significant.¹⁷

Postoperative pain was also shown to be more common among those who had received BPTB autografts in Magnussen's SR. In three of the included studies a significantly greater number of patients reported postoperative anterior knee pain in the BPTB autograft groups. In four of the included studies, patients who received a BPTB autograft reported kneeling pain more commonly than patients who received hamstring grafts although this was only deemed statistically significant in 3 of these

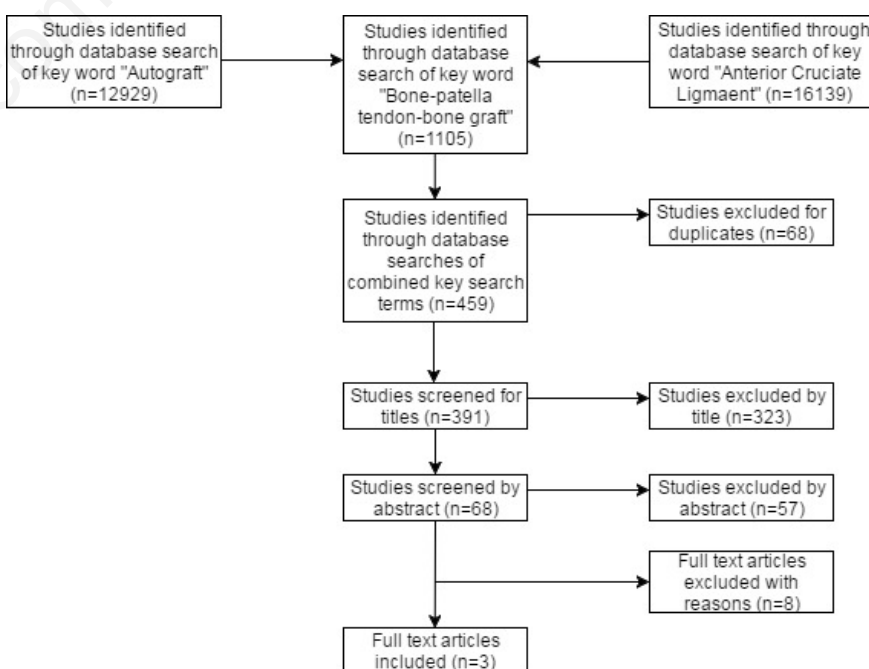


Figure 2. Flow diagram of the literature search comparing bone-patellar tendon-bone autograft to hamstring autograft anterior cruciate ligament reconstruction.

studies.¹⁸ As all of the studies reported similar results for this outcome, we deemed that patellar-tendon use results in a statistically greater chance of anterior knee and kneeling pain than hamstring-tendon autograft use.

Discussion

Careful consideration of patients' activity levels, willingness to cooperate with a rehabilitation program and other associated co-morbidities may affect the decision to operate on a patient with an ACL injury. Many patients may return to preinjury activity levels without the need for operative intervention.¹⁷ However, for more active patients who undertake activities that will be affected by poor knee stability surgical reconstruction of the ACL may be the best option.¹⁹

The goal of ACL reconstruction is providing long-term stability to the joint and to avoid subsequent lesions of the menisci and the development of degenerative joint disease. Choice of graft along with other factors including operative technique and postoperative rehabilitation are the main factors affecting this goal.

When comparing autografts to allografts we found that allografts were associated with higher rates of graft failure. Interestingly, allografts were also associated with shorter recovery times and less postoperative pain. This could allow an earlier return to high levels of activity that may in turn increase the likelihood of re-injury. Allografts also show slower integration into host tissue, may be another reason for higher rates of graft failure.

When comparing the different types of autograft technique, we found that BPTB grafts were associated with greater knee stability and reduced laxity of the ACL.^{16,17} One of the possible reasons for this is that the patellar tendon is stiffer and less flexible than the ACL, therefore enabling greater stability of the joint but also potentially restricting its ROM.²⁰ Indeed, two of the reviews indicated reduced knee extension with BPTB autografts.^{16,17} In contrast Hamstring tendon autografts were associated with greater laxity of the ACL but with lower rates of postoperative knee pain.¹⁶⁻¹⁸

There is currently no National Institute of Clinical Excellence (NICE) guidance surrounding autograft (including patellar-tendon and hamstring-tendon) and allograft ACL repair, which may have indicated a first line treatment. The only advice related to the topic is that of ligament augmentation reconstruction system, a synthetic alterna-

tive to autograft and allograft use.²¹ However, guidance published jointly by the British Orthopaedic Association, the British Association for Surgery of the Knee and the British Orthopaedic Sports Trauma Association regarding primary isolated ACL reconstruction is available and recommends to tailor graft choice on an individual basis.²² As such there is little guidance for healthcare professionals to determine which graft should be used. Therefore, it may be deemed that graft type becomes the decision of individual patients and professionals. When a patient is faced with the decision of which autograft they wish to receive it must be considered whether knee stability or limited postoperative pain is the key priority. For patients who undertake activities involving a lot of kneeling it seems that Hamstring autografts may be a more suitable option as we found that they were associated with less pain post operatively.

Opportunities for future research

The radiographic results of 2 studies included in Magnussen *et al.*'s 2011 review showed significantly higher rates of tibiofemoral osteoarthritis in patients who had received BPTB autografts suggesting that this autograft type may lead to higher rates of osteoarthritis.¹⁶ Further research with longer follow up of patients analyzing clinical and patient reported outcomes and radiographic data for signs of osteoarthritis may be useful to distinguish which autograft is associated with fewer long term complications. In order to complete this, RCTs with follow up extending for more than 10 years could be completed.

Since there is currently no defining research to suggest that one autograft choice is more beneficial than another, a cost effectiveness analysis of BPTB autografts when compared to hamstring autografts could be undertaken to provide more information to decision makers about which autograft technique to adopt. This could be incorporated into development of NICE guidance surrounding graft use in ACL repair to provide healthcare professionals with a uniform approved pathway for patient treatment.

Conclusions

When attempting to identify whether autografts or allografts are more effective for the reconstruction of the ACL in an active population we found no significant statistical differences in regards to long-term pain, laxity, ROM, patient reported outcomes, and return to preinjury levels of activity. There were statistically significant

differences in short-term outcomes, which included reduced tunnel widening and reduced risk of graft failure with autografts.^{14,15} However, a complication of autograft use is donor site morbidity including patellofemoral osteoarthritis, patellofemoral pain and loss of knee extension.^{14,15} Allografts, despite increased risks of graft failure, have the advantages of being readily available and being associated with a lower risk of postoperative knee stiffness.^{14,15}

When comparing post-operative outcomes for BPTB autografts and hamstring autografts we discovered that BPTB autografts were associated with significantly greater knee stability and reduced laxity of the ACL.^{16,17} However, BPTB autografts were also associated with more postoperative anterior knee pain and kneeling pain.^{16,17}

After analyzing the evidence, we were unable to clearly identify which graft choice results with a superior functional result and lower number of complications, as each graft is associated with different benefits and risks. Further cost-effectiveness analyses and studies analyzing long term follow up of patients would be helpful to provide more information about the different graft types. However, currently we believe decisions about graft choice should be made on an individual basis.

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