Anterior Cruciate Ligament reconstruction, hamstring versus bone–patella tendon–bone grafts: a systematic literature review of outcome from surgery

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Abstract

The Anterior Cruciate Ligament (ACL) is regarded as critical to the normal functioning of the knee, its disruption causing functional impairment. In recent years central third of the patellar tendon (PT) and combined Semitendinosis and gracilis tendons (HT) have become the most frequently used graft types for anterior cruciate knee ligament reconstruction. For the past two decades, the gold standard in ACL reconstructions has been the PT, but increasingly the HT graft has been used. This shift in popularity has occurred for several reasons, including concerns about damaging the knee extensor apparatus using the PT procedure, but potential complications also exist with HT techniques. Despite the vast amount of literature on ACL reconstruction and its outcome, there are very few controlled randomised studies directly comparing the two most commonly used tissue grafts. This review aimed to examine the data available from randomised trials, in order to combine and evaluate the best available evidence for choice between these two popular tissue grafts for use in ACL reconstruction. A literature search revealed 13 studies, which met the inclusion criteria of the review. The results of the 13 studies included in this review suggest that there is no significant evidence to indicate that one graft is superior. Both the PT and HT grafts appear to improve patients’ performance, and therefore both would be good choices for ACL reconstruction.

1. Introduction

The Anterior Cruciate Ligament (ACL) is regarded as critical to the normal functioning of the knee, its disruption causing functional impairment, meniscal lesions, and the early onset of joint degeneration [1]. Injury of the ACL is now the most common ligamentous injury of the knee and accounts for about 30 injuries per 100,000 of the population [2], with greater than 100,000 new ACL injuries occurring each year [3]. No definitive management strategy exists for patients with this injury, a case particularly evident when deciding between conservative rehabilitation and reconstruction, and between methods of reconstruction [4].

With surgical intervention, several surgical procedures are available including mini-arthrotomy open technique; two-incision arthroscopically assisted techniques, and one incision endoscopic technique [5]. Currently, ACL reconstruction is most often performed using an arthroscopically assisted technique [2]. Both biological and non-biological tissues can be used to provide the donor graft; these include patella tendon, semitendinosus/gracilis tendon, distal iliotibial tract, fascia lata and synthetic ligaments [2]. The biological tissue grafts are available either as autografts or allografts.

In recent years, central third of the patellar tendon (PT) and combined Semitendinosis and gracilis tendons (HT) have become the most frequently used graft types for anterior cruciate knee ligament reconstruction [6]. For the past two decades, the gold standard in ACL reconstructions has been the patellar tendon graft from the middle third of the patella tendon [7], but increasingly the HT graft has been used. This shift in popularity has occurred for several reasons, including, concerns about damaging the knee extensor apparatus using the patella tendon procedure and the potential for subsequent anterior knee pain, patella fracture, ligament rupture, and infra patella contraction [8].
Potential complications also exist with the hamstring techniques. Tunnel widening and fixation may be more of a problem in the hamstring procedure and there have been concerns about how the graft harvest procedure may affect the muscle function of the hamstring. When examining the literature though it would appear that the move towards hamstring graft has been achieved with little in the way of objective supporting data [8].

The best choice of tissue graft for use in ACL reconstruction has been the subject of much discussion. However, despite the amount of literature on ACL reconstruction and its outcome, there are very few clinically controlled, randomised studies directly comparing the two most commonly used tissue grafts, the bone–patella tendon–bone and the semitendinosus/gracilis tendon. Therefore this review aims to examine the data available from randomised trials, in order to combine and evaluate the best available evidence for choice between these two popular tissue grafts for use in ACL reconstruction.

The objective of this review was to assess the effectiveness of PT graft compared to HT graft as used in the treatment of ACL injuries of the knee. The null-hypothesis tested was that there is no difference in outcome between bone–patella tendon–bone (PT) graft versus semitendinosus and gracilis tendon (HT) graft.

2. Method

2.1. Criteria for considering studies for this review

2.1.1. Types of studies

Any randomised or quasi-randomised controlled trials, which evaluated surgical treatment of ACL injuries of the knee. A quasi-randomised trial refers to methods of allocating participants to a treatment, which are not strictly random (e.g. Date of Birth or alternation).

2.1.2. Types of participants

Adults/Teenagers of either sex, who have been diagnosed with an ACL injury in need of surgery.

2.1.3. Types of intervention

Trials comparing bone–patella tendon–bone graft to semitendinosus and gracilis (hamstring) tendon graft for reconstruction of ACL injuries. No other surgical interventions were accepted.

2.1.4. Types of outcome measures

Data for the following outcomes were sought:

- Recovery of activity, treatment failure and functional outcome
- Return to pre-injury level of sporting activity and achievement
- Pain
- Muscle strength
- Knee stability
- Range of motion
- IKDC Score (International Knee Documentation Committee)
- Re-operation
- Complications.

2.2. Search strategy for identification of studies

A search was carried out using the Cochrane Controlled Trials Register in the Cochrane Library (January 2003), MEDLINE (1996–2003), CINAHL (1982–2002) and INFOTRAC. Reference lists of published articles were then also hand-searched in an attempt to identify further studies. All studies included in this review were written in English. The following key words were used: Anterior Cruciate Ligament; Reconstruction; Knee Injuries; Athletic Injuries; Knee Ligaments; Outcome.

2.3. Assessment of methodological quality

Methodological quality was independently assessed, without masking of authors or sources using a subject-specific modification of the generic evaluation tool used by the Cochrane Musculoskeletal Injuries Group (2003) (see Appendix A). Studies were also graded using the criteria presented in the Cochrane Handbook (2003), for the quality of allocation concealment (adequate A, unclear B, inadequate C). Categorical and overall quality scores were calculated to enable exploratory analysis of relationships between studies.

3. Results

3.1. Description of studies

Research for this review resulted in the identification of 52 studies, 13 of which met the inclusion criteria of the review. Thirty-four studies were excluded, eight studies failed due to type of graft used, 25 studies failed due to non-randomisation, and 5 studies failed due to non-comparison of bone–patella tendon–bone graft with semitendinosus/gracilis graft.

In the 13 trials included in this review, 1145 participants were involved, of these the majority were male adults. Where reported, the mean ages of the trial participants ranged from between 20.1 and 32 years. Where stated, males always out-numbered the female participants. Although return to sports participation was often stated, information on sports participation as well as cause of injury was more limited. ACL injury was the main focus in all 13 trials. Where reported, the mean time from injury to surgery ranged from 10 weeks to 41.3 months. Out of the 13 studies included in this review, 9 of the studies only included
patients with ACL injuries, 1 study used patients with ACL and medial collateral ligament (MCL) injuries grade 2 or above, and 3 studies did not mention the exclusion criteria for participation. The individual studies are described in Table 1.

### 3.2. Methodological quality

The methodological quality of the 13 included papers were all classified as moderate; the difficulties in blinding of assessors; trial participants and treatment providers to the trial interventions meant that it was difficult to achieve a top score. The scores of the 11 items of methodological quality for the trials are presented in Table 2.

Treatment allocation (item A) was judged as concealed in four trials [6,8,10,19]. Allocation concealment was uncertain in four trials, two of which did not give any details of their method of randomisation [11,14]. Allocation was not concealed in five trials [9,12,16–18], using quasi-randomised methods such as alternation and birth date for treatment allocation.

Two studies [8,14] achieved a full score for intention to treat analysis (item B). Others failed to provide full information for post-randomisation exclusions or losses. There was no mention of assessor blinding (item C) and no indication of the method of randomisation [11,14]. Allocation was not concealed in five trials [9,12,16–18], using quasi-randomised methods such as alternation and birth date for treatment allocation.

The trials interventions and their application protocols (item I) were not defined in one trial [12]. The majority of the trials scored full points, adequately describing the interventions and their application protocols. Outcome measurements (item J) were clearly defined in 10 studies, adequately defined in 2 studies and only one study was poorly defined [17]. The accuracy and clinical relevance of the methods

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**Table 1**

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<th>Study</th>
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<tr>
<td>Aglietti et al.</td>
<td>PT with HT graft in 63 patients with chronic ACL injuries. The participants were surgically treated in an alternating manner using either patella tendon or the semitendinosus/gracilis grafts. Three patients (2 PT and 1 HT) were lost to follow-up. The remaining 60 patients (30 PT and 30 HT) were evaluated at follow-up. The follow-up period ranged from 22 to 39 months.</td>
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<td>Anderson et al.</td>
<td>Randomly assigned 105 patients to three treatment groups: PT graft; HT graft combined with a loose extra-articular iliotibial band tendonesis; and HT graft. Three patients were lost to follow-up, one from group 2 and two from group 3. The remaining 102 patients were re-examined after 24 months.</td>
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<td>Aune et al. [11]</td>
<td>Compared PT graft with HT graft in 72 patients. The participants were randomly assigned to two groups (35 PT and 37 HT), respectively. Three patients were excluded and eight were lost to follow-up. The remaining 61 patients (29 PT and 32 HT) were assessed at 6, 12 and 24 months.</td>
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<td>Beard et al. [8]</td>
<td>Randomly assigned 60 patients into two groups: PT group and HT group. Fifteen patients were lost to follow-up. The remaining 45 patients were assessed at 6 and 12 months.</td>
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<td>Carter and Edinger [12]</td>
<td>Randomly assigned 120 patients into three treatment groups: PT graft; semitendinosus graft (ST); HT graft. Standardised pre-operative and rehabilitation programmes were followed in all cases. Six patients were excluded, eight patients were lost to follow-up, the remaining 106 patients (38 PT, 33 ST, and 35 HT) were assessed at 6 months.</td>
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<td>Ejerhed et al. [13]</td>
<td>Compared PT with ST tendon graft in 71 patients. The participants were randomly assigned to two groups (35 PT and 36 ST), respectively. All patients were re-examined after a 2-year period.</td>
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<td>Eriksson et al. [14]</td>
<td>Randomly assigned 164 patients to two treatment groups: PT graft (84) or ST (80). The same rehabilitation protocol was used for all patients. Four patients were lost to follow-up. The remaining 160 patients were assessed at 24 months.</td>
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<td>Eriksson et al. [15]</td>
<td>Randomly assigned 107 patients to reconstruction either with PT graft (50) or ipsilateral HT graft (57). Eighteen patients were lost to follow-up. The same rehabilitation protocol was used for all patients. Eighty nine patients attended follow-up within the period of 20–35 weeks.</td>
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<tr>
<td>Feller et al. [6]</td>
<td>Compared PT graft with HT graft in a randomised study of 65 patients. Postoperatively all patients used a standard ‘accelerated’ rehabilitation protocol. All patients were reviewed after 2, 8 weeks and 4 months.</td>
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<tr>
<td>Jansson et al. [16]</td>
<td>Randomly assigned 99 patients to either PT graft or HT graft. The post-operative care and rehabilitation protocol was the same in both groups. Ten patients were lost to follow-up. Forty-three patients in the PT and 46 patients in the HT group were evaluated at 1 and 2 years post surgery.</td>
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<tr>
<td>Marder et al. [17]</td>
<td>Compared PT graft with HT graft in 72 patients. The participants were randomly assigned to groups of 37 (PT) and 35 (HT). Post operatively all patients participated in a standard rehabilitation protocol. All patients were evaluated at a minimum of 24 months.</td>
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**Table 1 (continued)**

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<th>Study</th>
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<tr>
<td>Shaieb et al. [18]</td>
<td>Randomly assigned 82 patients to receive either PT graft or HT graft. Twelve patients were lost to follow-up, leaving 33 patella tendon grafts, and 37 hamstring tendon grafts. Evaluation was performed with a minimum follow-up of 24 months. Thirteen patients were unable to attend clinical examination and only answered a questionnaire by mail.</td>
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<tr>
<td>Webster et al. [19]</td>
<td>Randomly assigned 65 patients to receive either PT graft or HT graft. All patients followed the same accelerated rehabilitation protocol. Four patients discontinued the study. The remaining 61 patients (33 HT and 28 PT) were assessed at 4 months, 1 and 2 years.</td>
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used (item K) were considered as optimal in 10 of the 13 studies, 2 studies were judged to be appropriate but not optimal and only one study was judged inappropriate [6].

Active surveillance, as detected by the prospective follow-up of all trial participants at set and clearly defined times, was the ‘norm’. Generally the duration of follow-up determined the score for the final item of the scoring scheme (item L). The length of follow-up was considered optimal (1 year or more) in 10 studies; only one study was judged inappropriate [6].

3.3. Outcome of studies

For the 13 studies included in this review, the results of the studies are arranged below by the outcome categories.

3.3.1. Return to pre-injury level of sporting activity

Five studies [8,13–16] used the Tegner activity score to evaluate the levels of activity. All five studies reported no significant differences between the PT groups and the HT groups. Beard et al. [8] reported scores of 5.7 in the PT group, 4.9 in the HT group at the 6 months follow-up, and 5.7 in the PT group, 4.3 in the HT group at the 12 months follow-up. Eriksson et al. [14] reported a score of 6 for both groups; the desired level had been set at 8. Eriksson et al. [15] reported that both groups had improved their scores compared with their pre-injury level. Four patients in the PT group and 6 in the HT group stated that their reduction in pain was anterior (87% vs. 51%), whereas more patients in the HT group said that their worst pain was posterior (49% vs. 13%). This difference did not continue over time, and at the 8-week and 4-month reviews the majority of patients in both groups reported the site of worst pain to be anterior in location. After 8 weeks there was no difference between the two groups in terms of the severity of general pain, but after 4 months the severity of general pain was higher in the PT group. Eriksson et al. [14] and Jansson et al. [16] reported at the 2-year follow-up that there were no significant differences between the groups with respect to patellofemoral pain. Both Aune et al. [11] and Eriksson et al. [14] reported that kneeling pain was significantly less common in the patients with the hamstring tendon graft. Aune et al. [11] also reported that AKP was slightly more common in the PT group after 12 months. Both Eriksson et al. [15] and Shaieb et al. [18] found that patellofemoral pain was more common in the PT group than the HT group. At 6 months post operation, Shaieb et al. [18] reported that 15 (48%) of the PT patients and 7 (20%) of the HT patients had patellofemoral pain. At the 2-year follow-up, 13 (42%) in the PT group and 7 (20%) in the HT group had patellofemoral pain. Five studies [8,9,10,12,19] did not report data on this category.

3.3.2. Pain

Three studies [6,13,17] all reported that no significant differences existed between the groups with respect to discomfort. However, Ejerhed et al. [13] reported that 6 out of 32 patients (19%) and Marder et al. [17] reported 17 of the 72 patients (24%) had experienced subjective anterior knee pain (AKP) following the ACL reconstruction. Feller et al. [6] reported that there was a significant difference in the location of pain. More patients in the PT group said that the site of their worst pain was anterior (87% vs. 51%), whereas more patients in the HT group said that their worst pain was posterior (49% vs. 13%). This difference did not continue over time, and at the 8-week and 4-month reviews the majority of patients in both groups reported the site of worst pain to be anterior in location. After 8 weeks there was no difference between the two groups in terms of the severity of general pain, but after 4 months the severity of general pain was higher in the PT group. Eriksson et al. [14] and Jansson et al. [16] reported at the 2-year follow-up that there were no significant differences between the groups with respect to patellofemoral pain. Both Aune et al. [11] and Eriksson et al. [14] reported that kneeling pain was significantly less common in the patients with the hamstring tendon graft. Aune et al. [11] also reported that AKP was slightly more common in the PT group after 12 months. Both Eriksson et al. [15] and Shaieb et al. [18] found that patellofemoral pain was more common in the PT group than the HT group. At 6 months post operation, Shaieb et al. [18] reported that 15 (48%) of the PT patients and 7 (20%) of the HT patients had patellofemoral pain. At the 2-year follow-up, 13 (42%) in the PT group and 7 (20%) in the HT group had patellofemoral pain. Five studies [8,9,10,12,19] did not report data on this category.

3.3.3. Muscle strength

Six studies [6,9,10,12,13,17] used a Cybex II dynamometer to measure muscle strength. Comparison of the isokinetic results between the PT and HT groups showed general similarities. Analysis of the results in each case failed to reveal significant differences between the two groups, both in terms of peak extension and flexion. Aglietti et al. [9] reported results for peak extension/flexion torques at 60, 120 and 180 deg/s (degrees per second). The average deficits were less than 10% except for the peak extension torque at 60 deg/s in the HT group, which was 89.37%. Ejerhed et al. [13] found that there was a significant improvement in strength in terms of both extension and flexion on the injured

Table 2
Methodological quality results

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side, regardless of the type of graft. At the follow-up however, there were no significant differences in strength, in terms of both flexion and extension between the injured and non-injured side, in either the PT or HT group. Feller et al. [6] reported larger extension deficits in the PT group than the HT group. These deficits were significant at high speed, and showed a trend towards significance at low speed. No differences were observed between the groups for flexion deficit. Marder et al. [17] found a significant weakness in peak flexion torque at 60 deg/s in the HT group, but found no significant differences in peak extension torque at 60 deg/s. Aune et al. [11] used a Cybex 6000 dynamometer at 60 and 240 deg/s. The results showed that the HT group, had better isokinetic knee extension strength and endurance after 6 months compared with the PT group. After 12 and 24 months however, no differences were found. There was a significant weakness in isokinetic strength at 60 deg/s in the HT group compared with the PT group at 12 months. At 240 deg/s the endurance flexion weakness was significant in the HT group at all follow-up intervals.

Using a Kin-com 125 isokinetic dynamometer, Beard et al. [8] found that muscle strength steadily improved over time, but a residual deficit in extension strength of 19% (compared to the non-injured limb) remained at the 1-year follow-up in both the PT and HT groups. The overall deficit in flexion strength compared to the control limb at 1 year was less; 13% in the HT group and 5% in the PT group.

Jansson et al. [16] reported that at the 1-year follow-up the isokinetic quadriceps muscle torque at 60 deg/s was significantly higher in the HT group than the PT group (85% vs. 79%). However, at the 2-year follow-up there were no significant differences between the HT and PT groups with respect to isokinetic muscle performance. Four studies [14,15,18,19] did not provide data for this category.

### 3.3.4. Knee stability

Eight trials [6,8,10,11,13,15–19] measured knee stability using the KT-1000 arthrometer, with four of these [8,10,11,18] measuring maximum side-to-side difference. Anderson et al. [10] and Shaieb et al. [18] both found significantly better stability in the PT groups compared to the HT groups (2.1 vs. 3.1 mm and 1.5 vs. 2.5 mm). Aune et al. [11] and Beard et al. [8] found no significant differences between the two groups. Two studies [6,19] reported side-to-side difference at 67 N (Newtons). Feller et al. [6] found that the side-to-side difference was significantly greater in the HT group (0.5 vs. 1.2 mm), however, even though Webster et al. [19] found no significant difference, there was an increase in the HT group compared to the PT group (0.7 vs. 1.4 mm). Three studies [13,17,18] reported side-to-side difference at 89 N. Marder et al. [17] reported no significant difference between the two groups (1.6 mm PT and 1.9 mm HT). Shaieb et al. [18], however, did find a significant difference between the two groups (1.4 mm PT and 2.4 mm HT). Ejerhed et al. [13] found that the side-to-side difference decreased significantly from before the operation to follow-up in the PT group, but in the HT group the decrease did not reach significance. In terms of absolute values the anterior laxity decreased significantly in both groups. Three studies [6,18,19] reported side-to-side difference at 134 N. They found no significant difference between the PT and HT groups, however both of the HT groups had a higher instability compared with the PT groups.

Aglietti et al. [9] measured knee stability with a KT-2000 arthrometer. A side-to-side difference in tibial displacement over 5 mm was accepted as a limit of graft failure. Ten percent of the PT grafts failed at 91 N, 13% at 136 N, and 20% at the manual maximum testing. In the HT group the results were 13% at 91 N, 20% at 136 N, and 23% at manual maximum testing. The differences between the two groups were not significant.

Both Eriksson et al. [14] and Eriksson et al. [15] used a Stryker laxity test to measure knee stability. Eriksson et al. [15] found no significant difference in side-to-side laxity at 20 lb in the PT or HT group. Eriksson et al. [14] found that the majority of PT and HT patients had a side-to-side difference between −1 and 2 mm at 91 N. At 182 N the majority of patients in both groups had a side-to-side difference between 3 and 5 mm.

Jansson et al. [16] used a CA-4000 to measure knee stability. They found that the side-to-side difference was 1.7 mm in the PT group and 1.2 mm in the HT group. There were no significant differences between the two groups. Six studies [10,14–18] used the pivot shift test to measure knee stability. All six studies found that the majority of participants had a normal pivot shift 2 years post surgery.

### 3.3.5. Range of motion

Seven studies [6,10,11,13,15–17] found no significant difference in range of motion between the PT and HT groups. Marder et al. [17] found that 74% of patients (24 PT and 29 HT) had full range of motion post-operatively. Anderson et al. [10] reported that three patients in the PT group failed to gain 3° to 5° of extension and one patient lost 17° of flexion. In the HT group one patient lost 3° of extension and two patients lost 6° to 10° of flexion when compared with the non-injured side. Eriksson et al. [15] reported that 95% of patients in the PT group and 98% in the HT group had less than 3° extension deficit. Eighty-eight percent in the PT group and 79% in the HT group had a 0° to 5° flexion deficit. Feller et al. [6] found a mean flexion deficit of 14° in the HT group and 16° in the PT group. The mean extension deficit was 2° in the HT group and 3° in the PT group. Ejerhed et al. [13] reported that the range of motion was −5° to 145° in the PT group and −5° to 150° in the HT group. Jansson et al. [16] reported a mean extension of 0.5° in the PT group and 0.2° in the HT group. There was no difference in flexion with a mean of 140° of flexion in both groups. Four studies [9,14,18,19] revealed some differences in range of motion between the groups. Aglietti et al. [9] reported 47% in the PT group with a 1° to 3° extension deficit and 3% with a 4° to 5° extension

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deficit. In the HT group, a 1° to 3° extension deficit was found in only one knee (3%). The difference was significant. A minor 1° to 5° flexion deficit was present in 20% of both groups. Eriksson et al. [14] found a significant extension deficit of 3° or more in the PT group, but there was no significant difference in the flexion deficit between the PT and HT groups. Webster et al. [19] reported 57% in the PT group with a 0° to 3° extension deficit and 84% in the HT group. Shaieb et al. [18] reported 52% in the PT group and 27% in the HT group had a loss of motion. The deficit was in flexion rather than extension, with the average flexion deficit 7.5° in the PT group and 4.8° in the HT group. Two studies [8,12] did not report any data for this category.

3.3.6. IKDC

Seven studies [8,10,13–16,19] used the IKDC questionnaire to evaluate overall knee function. Eriksson et al. [14], Ejerhed et al. [13] and Jansson et al. [16] found no significant differences between the PT and HT groups with respect to IKDC evaluation scores. Beard et al. [8] found no significant differences between the two groups at 6 or 12 months, however, he reported that the IKDC grading demonstrated improvement over time in both groups, with 50% of all patients achieving either grade A or B (normal or near normal) at the 1-year follow-up. Anderson et al. [10] revealed a higher incidence of grade A or B results in the PT group compared to the HT group. Feller et al. [6] reported a significant difference in the IKDC scores between the two groups, with the HT group scoring higher than the PT group. However, it was concluded that the difference in findings between the groups may in fact be a result of the underlying different general pain scores between the groups. Webster et al. [19] reported that four patients (2 PT and 2 HT) scored a grade D (severely abnormal) IKDC rating. In all four cases this was due to a poor score in the symptoms category. Two of these patients were not undertaking moderate or strenuous activities (one due to pregnancy and one due to ceasing sporting activities). Six studies did not use the IKDC questionnaire [9,11,12,15,17,18].

3.3.7. Re-operation

A total of 76 patients required additional surgery, 20 in the PT groups and 54 in the HT groups. Seven studies [8,9,12–14,17,19] did not report data for this category. Table 3 lists the operations required by the patients as reported.

<table>
<thead>
<tr>
<th>Operative procedure</th>
<th>HT patients</th>
<th>PT patients</th>
<th>Article</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revision surgery for graft failure</td>
<td>10</td>
<td>6</td>
<td>10,11,14,15,16,17,18</td>
</tr>
<tr>
<td>Meniscal surgery</td>
<td>7</td>
<td>7</td>
<td>10,11,14,17</td>
</tr>
<tr>
<td>Screw/Staple removal</td>
<td>37</td>
<td>3</td>
<td>10,14,16</td>
</tr>
<tr>
<td>Notch plasty</td>
<td>1</td>
<td>4</td>
<td>14</td>
</tr>
</tbody>
</table>

3.3.8. Complications

Complications were reported in seven studies, with a total of 14 patients suffering some form of post-operative complication. Seven were from the PT groups and seven from the HT groups. The reported complications are displayed in Table 4. The remaining four studies [8,9,12,13] did not provide data for this category.

4. Discussion

Arthroscopic reconstruction using either the PT or HT grafts has become a frequently used intervention for the repair of ACL injuries. The aim of this review was to evaluate the effectiveness of these two grafts by comparing the results of 8 specific outcomes in 13 randomised or quasi-randomised studies involving 1145 patients. The methodology of all 13 studies was considered flawed, particularly regarding the lack of blinding of allocation concealment, during treatment and outcome assessors, with all studies scoring zero in these categories. Other factors should also be considered when comparing specific outcomes of multi-component interventions, such as: changes in surgical procedure; fixation technique; time from injury to surgery; the incidence of meniscal or other ligament injuries at the time of operation and type of rehabilitation protocol. These factors also have an effect on the applicability of the trial results, however, these issues are not reported on in this review.

4.1. Return to pre-injury level of activity

Five studies [8,13–16] used the Tegner activity score to evaluate the levels of activity. In all cases, both grafts produced similar improvements, with scores ranging from 4.0 to 6.1 in the PT groups and 4.0 to 6.5 in the HT groups. However, Beard et al. [8] and Ejerhed et al. [13] found that the activity level was reduced by 2 to 3 units on the Tegner scale in both groups, compared with their pre-injury level. Aglietti et al. [9] showed that a greater number of the PT group performed agility sports or sports involving pivoting, cutting and jumping (80% vs. 43%). It was decided that the lower level in the HT group was not attributed to a feeling of instability, but appeared to be due to the decreased motiva-
tion of the patients to participate in high risk sports. Marder et al. [17], Webster et al. [19] and Shaieb et al. [18] all reported that overall there was no significant difference between the PT grafts and the HT grafts, and that most patients returned to their pre-injury level of activity. These results were consistent throughout the studies suggesting that there was no significant difference between the PT and HT groups regarding return to pre-injury level.

4.2. Pain

According to Sachs et al. [20], one of the donor-site problems encountered after harvest of a patella tendon graft is persistent anterior knee pain (AKP). This was not, however, confirmed in the included studies. Marder et al. [17] noted that 24% of their patients reported AKP, but no difference with respect to the type of graft was observed. Aune et al. [11] found that AKP was slightly more common in the PT group at 12 months, but at 24 months there was no significant difference between the PT and HT groups. Ejrerhed et al. [13] was not able to demonstrate any significant difference between the PT and HT groups. At the 2-year follow-up Marder et al. [16] found no evidence to support a lower incidence of AKP after cruciate surgery. Eriksson et al. [14] and Webster et al. [19] all found greater knee stability than the patients in the HT groups. These findings are in line with Otero and Hutchieson [23], who also found greater knee stability with PT reconstruction. Holmes et al. [24] also demonstrated a trend towards better objective stability when using the PT graft. In contrast, the other four studies [8,11,17,19] also using the KT-1000 arthrometer to evaluate knee stability, found that the PT patients had less residual anterior translation, and therefore greater knee stability than the patients in the HT groups. These findings may have affected the validity of the results, thus favouring one graft over the other. When values at 134 N of force were recorded, Feller et al. [6] and Shaieb et al. [18] also found no significant difference between the groups. No significant differences were also found by Eriksson et al. [14] and Eriksson et al. [15] who used the Stryker test; Aglietti et al. [9], who used the KT-2000 arthrometer; and Jansson et al. [16], who used the CA-4000. The pivot shift test also revealed no significant difference between the two groups.

4.4. Knee stability

Four of the eight studies [6,10,13,18], which used a KT-1000 arthrometer to evaluate knee stability, found that the PT patients had less residual anterior translation, and therefore greater knee stability than the patients in the HT groups. These findings are in line with Otero and Hutchieson [23], who also found greater knee stability with PT reconstruction. Holmes et al. [24] also demonstrated a trend towards better objective stability when using the PT graft. In contrast, the other four studies [8,11,17,19] also using the KT-1000 did not find a difference in residual laxity, between the two groups, but Webster et al. [19] found slightly better results in the PT group. These differences between the studies could have been due to different intensity of rehabilitation. The lack of blinding during treatment and assessment may have affected the validity of the results, thus favouring one graft over the other. When values at 134 N of force were recorded, Feller et al. [6] and Shaieb et al. [18] also found no significant difference between the groups. No significant differences were also found by Eriksson et al. [14] and Eriksson et al. [15] who used the Stryker test; Aglietti et al. [9], who used the KT-2000 arthrometer; and Jansson et al. [16], who used the CA-4000. The pivot shift test also revealed no significant difference between the two groups.

4.5. Range of motion

Limitation of extension used to be a problem after ACL reconstruction, particularly when using the patella tendon, but now, with early mobilization and passive full extension, the problem is minimized [9]. The majority of the included studies demonstrated no significant difference in range of motion following either PT or HT reconstruction. Contrary to the majority findings, Aglietti et al. [9], Eriksson et al. [14] and Webster et al. [19] all found greater extension...
deficit in the PT groups. Given that the patella tendon graft is stiffer than the hamstring graft [25,26], these results are not unexpected. However, overall, no significant difference could be justified.

4.6. IKDC

The overall results of five studies [10,13,14,16,19] revealed that the majority of patients in both the PT and HT groups had normal or nearly normal knees at the 2-year follow-up. The results from Eriksson et al. [14] (60% PT vs. 55% HT), Webster et al. [19] (61% PT vs. 61% HT) and Ejerhed et al. [13] (53% PT vs. 59% HT) were worse than those from Anderson et al. [10] and Jansson et al. [16] who presented normal or nearly normal results of 97% PT vs. 79% HT and 79% PT vs. 84% HT, respectively. Only one study, Feller et al. [6] reported results of abnormal and severely abnormal (97% PT vs. 85% HT), but these results were judged to be inappropriate due to the timing of outcome measures (4 months).

4.7. Re-operations

There were more patients in the HT groups requiring further surgery than the PT group (54 vs. 20). The operations involved revision ACL, meniscal surgery, staple removal and Notch Plasty. This review was only concerned with the revision ACL and Staple removal surgery. The results for these two categories were revision ACL, 6 in the PT group Vs 10 in the HT group, and staple removal 3 in the PT group vs. 37 in the HT group. Jansson et al. [16] alone reported 32 patients requiring staple removal in the HT group. The high level of re-operations in the HT groups was probably due to the fixation technique, rather than the graft type, and therefore unfairly distorted the statistics.

4.8. Complications

Complications were reported in both the PT and HT groups (7 PT vs. 7 HT). These included infections, blow-out fractures, graft harvesting and range of motion problems. There was no difference with respect to complications between the groups.

5. Conclusion

The literature suggests that there continues to be much discussion regarding the ideal graft choice for ACL reconstruction. There are strong advocates for both PT and HT grafts, some suggesting that the PT provide better stability and others indicating lower incidence of PFP with the HT graft. The results of the 13 studies included in this review suggest that there is no significant evidence to indicate that one graft is more effective than the other. Both the PT and HT grafts appear to improve patients' performance, and therefore both would be good choices for ACL reconstruction. There is, however, a need for further research involving quality, large scale, randomised trials comparing the same criteria (surgical technique, fixation technique, rehabilitation protocol and outcome measures) in order to fully assess the effectiveness of these two popular tissue grafts.

Appendix A. Methods of review questions

A. Was the assigned treatment adequately concealed prior to allocation?

Score 2 if method did not allow disclosure of assignment.
Score 1 if there was a small but possible chance of disclosure.
Score 0 if method was quasi-randomised or open list/tabs were used.

B. Were the outcomes of patients who withdrew described and included in the analysis (intention to treat)?

Score 2 if intention to treat analysis based on all cases randomised was possible or had been carried out.
Score 1 if the number and reasons for withdrawal were stated but intention to treat analysis was not possible.
Score 0 if issue not mentioned or not possible.

C. Were the outcome assessors blinded to treatment status?

Score 2 if effective action had been taken to blind assessors.
Score 1 if there was a small or moderate chance of unblinding assessors.
Score 0 if not mentioned or not possible.

D. Were important baseline characteristics reported and comparable at entry? These were taken to be previous knee surgery, current knee injury, duration of condition, level of activity, age and gender.

Score 2 if there was good comparability of groups, or confounding had been adjusted for in the analysis.
Score 1 if confounding was small and mentioned but not adjusted for.
Score 0 if there was a large potential for confounding, or if it was not discussed.

E. Were the participants blind to assignment status after allocation?

Score 2 if effective action had been taken to blind participants.
Score 1 if there was a small or moderate chance of unblinding of participants.
Score 0 if blinding was not possible, or not mentioned (unless double-blind), or possible but not done.

F. Were the treatment providers blind to assignment status?

Score 2 if effective action had been taken to blind treatment providers.
Score 1 if there was a small or moderate chance of unblinding of treatment providers.
Score 0 if blinding was not possible, or not mentioned (unless double-blind).

G. Were care programmes, other than the trial options, identical? Examples were training programs, advice on activity/mobilisation, follow up producers/

Score 2 if the care programmes were clearly identical.
Score 1 if they were clear but trivial differences.
Score 0 if the issue was not mentioned or if there were clear and important differences in care programmes.

H. Were the inclusion and exclusion criteria clearly defined?

Score 2 if they were clearly defined.
Score 1 if they were inadequately defined.
Score 0 if they were not defined.

I. Were the interventions clearly defined?

Score 2 if clearly defined interventions were applied with a standardised protocol.
Score 1 if clearly defined interventions were applied but the application protocol was not standardised.
Score 0 if the intervention and/or application protocol were not mentioned.

J. Were the outcome measures used clearly defined? (This was based on the outcome measures: return to full activity, muscle strength, knee stability, range of motion and IKDC.)

Score 2 if they were clearly defined.
Score 1 if they were inadequately defined.
Score 0 if they were not defined.

K. Were diagnostic tests used in outcome assessment clinically useful? (This was based on the outcome measures: return to full activity, muscle strength, knee stability, range of motion and IKDC.)

Score 2 if the accuracy and precision were established for measures used, and were comparable with the best available.
Score 1 if the accuracy and precision were established but were significantly below the best available.
Score 0 if accuracy and precision were not established for the method used.

L. Was the surveillance active, and of clinically appropriate duration?

Score 2 if active surveillance and optimal timing of outcomes measures (1+ years).
Score 1 if active surveillance and appropriate but not optimal timing of outcome measures (6 to < 12 months).
Score 0 if surveillance not active and/or the timing of outcome measures is judged to be inappropriate (< 6 months) or is undefined.

References

patellar tendon grafts in reconstruction of the anterior cruciate ligament. JBJS (Br) 2001;83-B:348–54.


