Insufficient evidence to support peroneus longus tendon over other autografts for primary anterior cruciate ligament reconstruction: a systematic review

Theodorakis Marin Fermín,1,2 Jean Michel Hovsepian,3 Panagiotis D Symeonidis,4 Ioannis Terzidis,2,4 Emmanouil Theodor Papakostas2,5

ABSTRACT

Importance Graft choice for anterior cruciate ligament reconstruction (ACLR) remains a subject of interest among orthopaedic surgeons because no ideal graft has yet been found. Peroneus longus tendon (PLT) has emerged as an alternative autograft for reconstruction in kneeling populations and in simultaneous anterior cruciate ligament (ACL) and medial collateral ligament (MCL) injuries.

Objective To evaluate the current evidence on the outcome of primary ACLR with PLT autograft in adults and donor ankle morbidity, in addition to determining the average PLT graft dimensions from published studies.

Evidence review Two independent reviewers searched PubMed, CENTRAL, EMBASE, Scopus and Virtual Health Library databases using the terms “anterior cruciate ligament,” “peroneus longus” and “fibularis longus” alone and in combination with Boolean operators AND/OR. Studies evaluating clinical and stability outcomes, graft-donor ankle morbidity and graft dimensions of PLT in ACLR were included. Methodological quality was assessed using the Modified Coleman Methodology Score (mCMS). A narrative analysis is presented using frequency-weighted means wherever feasible. Publication bias was assessed using the ROBIS tool.

Findings Twelve articles with intermediate-level methodological quality were included. Eight studies assessing the clinical and stability outcomes of reconstruction with PLT showed satisfactory outcomes, similar to those of hamstring tendons (HT). No studies assessed anterior knee pain as an outcome. Six studies evaluated the graft-donor ankle morbidity using general functional foot and ankle scores and non-validated tools, showing favourable outcomes. Nine studies assessed PLT graft diameter, revealing grafts consistently larger than 7 mm among the different preparation techniques, which is comparable with reports of HT grafts.

Conclusions and relevance The clinical and stability outcomes of ACLR with different PLT autograft preparation techniques are comparable with those of HT during short-term follow-up; however, there is insufficient evidence to support its use in the populations that motivated its implementation. Thus, stronger evidence obtained with the use of validated tools reporting negligible donor-graft ankle morbidity after PLT harvesting is required prior to recommending its routine use, despite the consistency of its dimensions.

Level of evidence Level III.

What is already known

► There is no consensus regarding the ideal graft for anterior knee reconstruction.
► Anterior knee pain is a common complication following anterior cruciate ligament reconstruction with bone-patellar tendon-bone graft.
► Peroneus longus autograft has been proposed as an option for anterior cruciate ligament reconstruction, especially in the kneeling populations and in simultaneous anterior cruciate ligament and medial collateral ligament injury.

What are the new findings

► Clinical and stability outcomes following anterior cruciate ligament reconstruction with the peroneus longus tendon are comparable with those of hamstring tendon autografts at the 2-year follow-up.
► Evidence regarding graft-donor ankle morbidity after peroneus longus tendon harvesting should be interpreted carefully since most patients are assessed using general functional foot and ankle scores and non-validated tools.
► Peroneus longus tendon graft diameter is consistently larger than 7 mm and is comparable with that of the hamstring tendons regardless of the preparation technique.
► Insufficient evidence is available regarding the incidence of anterior knee pain following anterior cruciate ligament reconstruction with a peroneus longus autograft.

INTRODUCTION

Anterior cruciate ligament reconstruction (ACLR) is among the most common procedures in orthopaedic surgery, yielding good-to-excellent outcomes and patient satisfaction.1-3 Although extensively investigated, several technical issues remain under discussion, including tunnel placement, number of bundles, fixation and graft selection.4-6

The patellar tendon (PT) has been considered the ‘gold standard’ graft in primary ACLR, especially in young and active patients.5,7 However, concerns about donor-site morbidity, including anterior knee pain associated with PT harvesting,
have directed the trends towards other autograft options in some populations.8–11

The quest for the ideal graft is defined by (1) reproduction of the native ligament size and biomechanical properties; (2) its integration potential; (3) the safety, ease and accessibility for harvesting with limited subsequent functional impairment; and (4) cost-effectiveness.6 12 13 Despite the orthopaedic community having not yet reached a consensus regarding the ideal graft,4 improvements in knee stability and function have been achieved with many graft types.8 14 Among the existing options, each possessing advantages and drawbacks, surgeons individualise the graft choice during preoperative planning according to the patient’s demands and injury characteristics.8 9

Pain-free kneeling in Asian and Islamic populations is a mandatory consideration since they perform several daily-living, social and religious activities in this position.8 16 17 This is also true for specific athletes such as wrestlers.18 Therefore, ACLR with hamstring tendons (HT) has increased in popularity in recent years as an autograft option.16

HT presents several advantages including high strength and stiffness, low harvest morbidity and improved device fixation8 9 19–21; however, its unpredictable size22 23 and novel evidence strongly correlating its use with anterior knee pain24 have shifted the relevant research towards other primary or salvage graft choices.8 12 22 23 This is especially important in the presence of concomitant injuries that may contribute to further instability in the absence of the hamstrings.8 26

Currently, PLT is emerging as a promising autograft option9 12 25 27 and has been widely implemented in orthopaedic procedures such as reconstruction of the medial patellofemoral ligament, spring ligament and deltoid ligament.29–31 Since the first report describing its use in ACLR by Kerimoglu et al.,27 evidence has increased over the last decade with encouraging results.8 9 12 22 25 32–33

Thus, the following systematic review aimed to evaluate the current evidence regarding the outcome of primary ACLR with PLT autograft in adults.

**METHODS**

The present systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

The purpose of this study was to (1) evaluate the current evidence regarding the outcome of primary ACLR with PLT autograft in adults, (2) evaluate the postoperative outcome of the graft-donor ankle morbidity, and (3) determine the average PLT graft diameter and length among the studies.

**Search strategy**

Eligible studies were identified by two independent reviewers (TMF, JMH) searching the PubMed, Cochrane Central Register of Controlled Trials (CENTRAL), EMBASE, Scopus and Virtual Health Library – PAHO databases up to 11 May 2020. The following terms “anterior cruciate ligament,” “peroneus longus” and “fibularis longus” were used alone and in combination with Boolean operators AND/OR.

**Eligibility criteria**

Clinical studies evaluating the outcome of primary ACLR with PLT autograft in adults were considered eligible for this systematic review if the following predefined criteria were fulfilled: (1) written in English or Spanish; (2) conducted in adult patients with anterior cruciate ligament (ACL) injury with/without concomitant MCL, meniscus or cartilage injuries; (3) patient outcome reported with a validated tool; (4) a minimum 1-year follow-up. Citation screening was performed on the potentially eligible articles, and a reference was included when it met our eligibility criteria. We excluded studies if they met one or more of the following criteria: (1) implemented PLT allograft and (2) included skeletally immature patients in the study population.

**Data extraction**

Two reviewers (TMF, JMH) independently reviewed the included studies, from which data were extracted and presented as a table. Data were extracted to a predefined Excel spreadsheet with the following variables: (1) author, year, and type of study; (2) number of patients; (3) patient characteristics; (4) graft, dimensions and measurement methodology; (5) ACLR technique; (6) follow-up; (7) outcomes; (8) complications.

Pooled data were reported using frequency-weighted means (WM).

**Methodological quality assessment**

The quantitative content assessment was performed using the Modified Coleman Methodology Score (mCMS) (table 1). Pearson’s test was employed to evaluate the possible association with publication year and highlight any changes in methodology over time.

**Assessment of publication bias**

Evaluation of the publication bias of the included studies was performed using the ROBIS tool.36

**RESULTS**

**Search results**

The initial literature search yielded 50 potentially relevant records following removal of duplicates. We screened titles and abstracts and retrieved 15 articles for full-text evaluation. Ten studies met the predetermined eligibility criteria, and two additional studies were included after citation screening8 12 37 (figure 1).

Of the 12 included studies, eight8 9 12 16 22 25 34 35 evaluated the clinical outcome (two randomised controlled trials, four case series and two prospective cohort studies), six8 9 16 22 25 37 evaluated the graft-donor ankle morbidity after ACLR with PL or half-PLT autograft, and nine8 13 25 34 35 37–39 assessed the autograft dimensions.

![Table 1 Modified Coleman Methodology Scores of the included studies](image-url)

<table>
<thead>
<tr>
<th>Study</th>
<th>LOE</th>
<th>Type of study</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sakai et al (2020)13</td>
<td>IV</td>
<td>Case series</td>
<td>46</td>
</tr>
<tr>
<td>Rhatomy et al (2019)14</td>
<td>II</td>
<td>Prospective cohort study</td>
<td>75</td>
</tr>
<tr>
<td>Rhatomy et al (2019)14</td>
<td>II</td>
<td>Prospective cohort study</td>
<td>73</td>
</tr>
<tr>
<td>Rhatomy et al (2019)14</td>
<td>I</td>
<td>Retrospective cohort study</td>
<td>50</td>
</tr>
<tr>
<td>Trung et al (2019)38</td>
<td>IV</td>
<td>Case series</td>
<td>51</td>
</tr>
<tr>
<td>Bi et al (2019)39</td>
<td>I</td>
<td>RCT</td>
<td>83</td>
</tr>
<tr>
<td>Khajotia et al (2018)40</td>
<td>IV</td>
<td>Case series</td>
<td>52</td>
</tr>
<tr>
<td>Shi et al (2018)41</td>
<td>I</td>
<td>RCT</td>
<td>71</td>
</tr>
<tr>
<td>Song et al (2018)42</td>
<td>IV</td>
<td>Case series</td>
<td>56</td>
</tr>
<tr>
<td>Anghang et al (2015)43</td>
<td>IV</td>
<td>Case series</td>
<td>53</td>
</tr>
<tr>
<td>Liu et al (2015)44</td>
<td>IV</td>
<td>Case series</td>
<td>59</td>
</tr>
<tr>
<td>Zhao et al (2011)45</td>
<td>IV</td>
<td>Case series</td>
<td>46</td>
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</table>

LOE, level of evidence; RCT, randomised controlled trial.
not being expressed separately from the other procedures evaluated in the study. Similarly, graft dimensions were not included in the study by Liu et al since they were hybrid grafts to salvage unqualified hamstring grafts for ACLR.

**Synthesis of results**

Narrative analysis of the collected data is summarised as follows:

ACLR with PLT autograft clinical and graft-donor ankle morbidity outcomes

Eight studies were included for clinical outcome and six for graft-donor ankle morbidity assessment (tables 2–4). Rahoty et al published the outcomes of a prospective cohort study in patients with isolated rupture of the ACL who underwent single-bundle ACLR with a two-strand PLT autograft. Excellent results were achieved in both the knee and the donor site according to the Modified Cincinnati, International Knee Documentation Committee (IKDC) and Tegner-Lysholm scores, a combination of hop tests, American Orthopedic Foot and Ankle Score (AOFAS) and Foot and Ankle Disability Index (FADI) at the 2-year follow-up. Similarly, Rahoty et al conducted a prospective cohort study in 52 patients with isolated ACL injuries and compared ligament reconstruction using two-strand PLT autograft versus four-strand HT autograft at the 1-year follow-up. No significant differences were found between the two groups with respect to the Modified Cincinnati, IKDC, Lysholm, AOFAS and FADI scores. Conversely, a significant reduction in thigh circumference was noted in the HT group.

**Table 2 Outcomes of anterior cruciate ligament reconstruction with peroneus longus and half-peroneus longus tendon autograft**

<table>
<thead>
<tr>
<th>Author, year and type of study</th>
<th>Number of patients</th>
<th>Patient characteristics and ACLR technique</th>
<th>Graft</th>
<th>Follow-up</th>
<th>Outcomes and complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhatomy et al 2019</td>
<td>75</td>
<td>Patients with isolated rupture of the ACL, Age: 26.7±8.57 (range 18–45), Gender: 59 males and 16 females</td>
<td>Two-strand PLT</td>
<td>2 years</td>
<td>Modified Cincinnati: pre 65.4±16.24, post 93.2±7.04</td>
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<td>IKDC: pre 54.6±14.02, post 95.6±3.35</td>
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<td>Tegner-Lysholm: pre 67.8±5.29, post 89.7±8.34</td>
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<td>No patients had thigh hypotrophy &gt;20 mm</td>
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<td>Single hop test: 91.4±2.45</td>
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<td>Triple hop test: 94.1±2.34</td>
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<td>Cross over hop test: 93.7±2.31</td>
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<td>Timed hop test: 93.7±4.10</td>
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<td></td>
<td>Eight studies were included for clinical outcome and six for graft-donor ankle morbidity assessment (tables 2–4).</td>
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<td>No significant differences were found between the two groups with respect to the Modified Cincinnati, IKDC, Lysholm, AOFAS and FADI scores. Conversely, a significant reduction in thigh circumference was noted in the HT group.</td>
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</tr>
</tbody>
</table>

**Figure 1** PRISMA flow diagram of the study selection process. PLT, peroneus longus tendon.

Regarding clinical or graft-donor ankle morbidity outcomes, some of the included studies were not considered for all the assessments due to (1) their short-term follow-up or (2) not being expressed separately from the other procedures evaluated in the study. Similarly, graft dimensions were not included in the study by Liu et al since they were hybrid grafts to salvage unqualified hamstring grafts for ACLR.
Table 3  Outcomes of studies comparing anterior cruciate ligament reconstruction with peroneus longus or half-peroneus longus tendon autograft vs hamstring tendon autograft

<table>
<thead>
<tr>
<th>Author, year and type of study</th>
<th>Number of patients</th>
<th>Patient characteristics and ACLR technique</th>
<th>Graft</th>
<th>Follow-up</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pholut et al 2019 Prospective cohort study&lt;sup&gt;73&lt;/sup&gt;</td>
<td>52 (PLT group: 24; HT group: 28)</td>
<td>Patients with isolated rupture of the ACL and concomitant grade III MCL injury</td>
<td>Two-strand PLT</td>
<td>1 year</td>
<td>Lysholm: pre 70.8±10.2, post 94.9±5.6</td>
</tr>
<tr>
<td>Bi et al 2018 Randomised controlled trial&lt;sup&gt;75&lt;/sup&gt;</td>
<td>124 (AHPLT group: 62; ST group: 62)</td>
<td>Patients with isolated primary rupture of the ACL, with or without grade I cartilage injuries</td>
<td>Four-strand AHPLT</td>
<td>2 years</td>
<td>KT-1000: pre 5.06±1.37, post 1.85±0.77</td>
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<tr>
<td>Shi et al 2018 Randomised controlled trial&lt;sup&gt;72&lt;/sup&gt;</td>
<td>38 (PLT group: 18; HT group: 20)</td>
<td>Patients with ACL and concomitant grade III MCL injury</td>
<td>Two-strand PLT</td>
<td>2 years</td>
<td>PT group: pre 90.13±3.01, post 94±6.81</td>
</tr>
<tr>
<td>Bi et al 2018 Randomised controlled trial&lt;sup&gt;75&lt;/sup&gt;</td>
<td>124 (AHPLT group: 62; ST group: 62)</td>
<td>Patients with isolated primary rupture of the ACL and concomitant grade III MCL injury</td>
<td>Four-strand AHPLT</td>
<td>2 years</td>
<td>KT-1000: pre 5.06±1.37, post 1.85±0.77</td>
</tr>
</tbody>
</table>

<sup>ACL, anterior cruciate ligament; ACLR, anterior cruciate ligament reconstruction; AHPLT, anterior half of the peroneus longus tendon; HT, hamstring tendons; IKDC, International Knee Documentation Committee; MCL, medial collateral ligament; PLT, peroneus longus tendon; ST, semitendinosus tendon; VAS, visual analogue scale.</sup>

Table 4  Donor ankle outcomes after anterior cruciate ligament reconstruction with peroneus longus and half-peroneus longus tendon autograft

<table>
<thead>
<tr>
<th>Author, year and type of study</th>
<th>Number of patients</th>
<th>Follow-up</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rhatomy et al 2019 Prospective cohort study&lt;sup&gt;39&lt;/sup&gt;</td>
<td>39</td>
<td>3 years</td>
<td>The median evaluation of the donor ankle was 3 years after surgery; no donor ankle complications were observed.</td>
</tr>
<tr>
<td>Bi et al 2018 Randomised controlled trial&lt;sup&gt;25&lt;/sup&gt;</td>
<td>24</td>
<td>1 year</td>
<td>The median evaluation of the donor ankle was 1 year after surgery; no donor ankle complications were observed.</td>
</tr>
<tr>
<td>Liu et al 2015 Case series&lt;sup&gt;22&lt;/sup&gt;</td>
<td>8</td>
<td>3 years</td>
<td>The median evaluation of the donor ankle was 3 years after surgery; no donor ankle complications were observed.</td>
</tr>
</tbody>
</table>

<sup>ACL, anterior cruciate ligament; AHPLT, anterior half of the peroneus longus tendon; ADL, American Orthopedic Foot and Ankle Score; FADI, Foot and Ankle Disability Index; HT, hamstring tendons; PLT, peroneus longus tendon; VAS-FA, visual analogue scale–foot ankle.</sup>
Moreover, in a randomised controlled trial (RCT) of isolated ACL injuries, Bi et al\(^\text{25}\) compared the use of a four-strand anterior half-peroneus tendon (AHPLT) autograft versus a four-strand semitendinosus tendon autograft. Each group comprised 62 patients and the authors found no statistical difference between the two groups with respect to the KT-1000, Lachman test, pivot shift test, IKDC, visual analogue scale (VAS) or AOFAS scores at the 2-year postoperative follow-up.

In an RCT of ACLR, Shi et al\(^\text{12}\) compared the use of a two-strand PLT autograft (18 patients) with a four-strand HT (20 patients) in simultaneous ACL and grade III medial collateral ligament (MCL) injury. No difference was found at the 6-month, 12-month or 24-month postoperative follow-up with respect to the KT-2000, Lachman test, IKDC, Lysholm or Tegner scores, the donor side ankle dorsiflexion or plantar flexion; and the dynamometric torque force was not statistically different at the 12-month or 24-month follow-up as compared with the preoperative level and healthy side.\(^\text{9}\)

Among the four case series in the present systematic review, Trung et al\(^\text{16}\) and Anghont et al\(^\text{18}\) reported satisfactory postoperative knee stability and patient-reported outcomes using three-strand and four-strand AHPLT or PLT autografts, respectively, in a combined total of 33 patients with ACLR and MCL injury and isolated ACL injury, respectively, at a minimum 1-year follow-up. The latter study\(^\text{18}\) showed a non-significant deterioration in VAS–foot or ankle dorsiflexion or plantar flexion; and the pivot shift test, IKDC, visual analogue scale (VAS) or AOFAS scores at an approximate 13-month follow-up.\(^\text{16}\)

In addition, two case series\(^\text{12,16}\) reported the use of a half-PLT autograft to salvage unqualified HT grafts in ACLR, showing moderate outcomes but comparable with those reported in the literature related to salvage tendon options. Liu et al\(^\text{22}\) reported an almost unaffected FADI score with no pain, discomfort, range of motion limitation or muscle power alteration as compared with the healthy ankle.

No peroneal nerve injury or any other major complications were reported as a result of graft harvesting among the studies.\(^\text{8,9,12,16,22,25,34,35}\) Nevertheless, Anghont et al\(^\text{16}\) reported bulging of proximal stumps in 20.8% (5), ankle joint stiffness in 8.3% (2), sural nerve neuropraxia in 8.3% (2) and ankle sprains in 4.2% (1) of the patients. These minor complications resolved spontaneously within 6 months of the surgery.

**Table 5** Peroneus longus and half-peroneus longus tendon autograft dimensions

<table>
<thead>
<tr>
<th>Author, year, and type of study</th>
<th>Number of patients</th>
<th>Graft dimensions (mean)</th>
</tr>
</thead>
</table>
| Sakki et al 2020 Case series\(^\text{19}\) | 20 | Two-strand PLT  
Length: 15.5±1.2 cm (males 15.7±1.0 cm, females 14.0±1.0 cm)  
Diameter: 8.1±0.8 mm (males 8.2±0.6 mm, females 7.0±0.0 mm).<7 mm: 0%, 7–8 mm: 60%, >8 mm: 40% |
| Rhatomy et al 2019 Prospective cohort study\(^\text{36}\) | 75 | Two-strand PLT  
Diameter: 8.38±0.68 mm (range 6.5–10.0) |
| Rhatomy et al 2019 Prospective cohort study\(^\text{36}\) | 52 (PLT group: 24; HT group: 28) | Two-strand PLT  
Diameter: 8.8±0.7 mm |
| Rhatomy et al 2019 Retrospective cohort study\(^\text{36}\) | 39 | Two-strand PLT  
Diameter: 8.56±0.82 mm |
| Trung et al 2019 Case series\(^\text{12}\) | 30 | Four-strand or three-strand AHPLT  
Length: 60±8.8 mm  
The graft was three-folded or four-folded to reach a minimum length of 60 mm  
Diameter: 7.0±0.8 mm. <7 mm: 16.67% (5) of patients, 7.0–7.5 mm: 66.67% (20) of patients, 7.5–8.0 mm: 16.67% (5) of patients |
| Bi et al 2018 Randomised controlled trial\(^\text{25}\) | 124 (AHPLT group: 62; ST group: 62) | Four-strand AHPLT  
Length: 6.4±0.5 cm  
Diameter: 8.0±0.7 mm |
| Khajotia et al 2018 Case series\(^\text{19}\) | 25 | Three-strand PLT  
Length: 28.1 cm (range 27–30)  
Diameter: 8.24 mm (range 7.5–9.5)  
8 mm grafts in 44% of the patients (11) |
| Shi et al 2018 Randomised controlled trial\(^\text{9}\) | 38 (PLT group: 18; HT group: 20) | Two-strand PLT  
Length: approximately 30 cm  
Diameter: 8–9 mm |
| Song et al 2018 Case series\(^\text{12}\) | 156 | Four-strand PLT  
Length: 8.5±0.4 cm (males 8.5±0.41 cm, females 8.2±0.39 cm)  
Diameter: 8.3±0.8 cm (males 8.49±0.76, females 7.75±0.62). <7 mm: 0%, 7–8 mm: 65.4%, >8 mm: 34.6% |

AHPLT, anterior half of peroneus longus tendon; HT, hamstring tendons; PLT, peroneus longus tendon.

grafs, but measurements were not performed using the same technique.13 25 34 37 39 From these results, a WM length of 30.1 cm prior to preparation of the graft can be estimated. Height13 38 39 and true leg length13 had the strongest correlation with the length and diameter of the PLT graft. Graft diameter has also been correlated with weight13 38 39 and gender39; however, conflicting evidence exists regarding its correlation with BMI.38 39 Song et al46 also found an association between a duration of ACL injury longer than 3 months and a thinner PLT graft diameter.

Methodological evaluation

The mCMS was used to assess the quality of the design of the studies included in the present systematic review. The average mCMS value was 63.9 (range 46–83), demonstrating an intermediate level of methodological quality. Of the mCMS items, ‘study size’ and ‘mean follow-up’ scored the lowest because five out of eight studies assessing clinical outcomes had less than 50 patients and the follow-up was only 12–36 months (WM 20.6 months). Furthermore, among these studies, four were case series.12 16 22 34 The descriptions of PLT harvesting were consistent and accurate in all studies, and the ACLR technique was adequately or fairly reported in all but one study.16 All studies adequately reported the selection criteria of the subjects involved and were unbiased, in addition to reporting clinical outcomes using at least one validated tool. Finally, the methods used for graft dimension measurement were not adequately reported in six out of nine studies.8 9 34 35 37 39 Pearson’s coefficient showed no significant association between the mCMS score and the year of publication (R=0.67, p=0.07).

Assessment of publication bias

The risk of bias in the review was found to be low (figure 2). However, due to the method used to identify and/or select studies, such as the language inclusion criteria and the included search databases, relevant papers written in different Asian languages and/or from regional databases may have been missed. Nevertheless, the present systematic review represents five of the major scientific databases and all the included studies were conducted in Asia.

DISCUSSION

The main findings of the present systematic review are as follows: (1) outcomes of ACLR with different PLT graft preparation techniques are comparable with those with HT at short-term follow-up; (2) the evidence on donor-site ankle morbidity after PLT harvesting for ACLR procedures is weak; (3) PLT graft dimensions are comparable with those of HT, but PLT diameters are consistently larger than 7 mm among studies. The PLT is gaining interest as an alternative autograft option among surgeons treating ACL injuries, especially in the kneeling populations.8 9 12 16 22 25 27 32–34 Moreover, the PLT also represents a valid option for patients with associated ACL and MCL injuries,9 34 in which there is a potential for additional medial instability after HT harvesting.40

Biomechanical studies have recommended a two-strand PLT as a suitable graft for ACLR.41 42 Studies on the tensile properties of 8 mm two-strand PLT have reported superior failure load and stiffness as compared with 10 mm PT grafts45 and native ACL.4 41 44 Similarly, comparable failure loads with HT have been published.9 44 In a cadaveric study conducted by Zhao et al, the AHPLT failure load was equivalent to that of the semitendinosus and approximately 1.5 times that of the gracilis tendon.12

The findings of the comparative studies included in the present systematic review indicate that outcomes of ACLR with PLT or half-PLT are comparable with those obtained with HT grafts at short-term follow-up.8 9 25 In addition, case series reporting stability and clinical outcomes of ACLR with different PLT preparation techniques, as the main or salvage graft, showed satisfactory results.12 16 22 34 Other authors have also reported similar experiences in their series of ACLR using PLT grafts.32 33 37 46

To date, Kerimoğlu et al27 are the only authors to report the clinical outcomes with a minimum 5-year follow-up in a group of 27 patients (mean age 30 years) undergoing ACLR and partial meniscectomy (48.3%). Clinical stability was assessed with Lachman and pivot shift tests, yielding normal findings in 41.4% (12) and 44.8% (13) of the patients, respectively. The IKDC scale was rated as normal or nearly normal in 58.6% (17) of the patients and as abnormal or severely abnormal in 41.4% (12). The Lysholm score (mean 83.7) was excellent or good in 79.3% (23) of the patients. Lastly, radiographic follow-up showed mild-to-moderate degenerative changes in 37.9% (11) of the patients. There are no studies available that report a longer follow-up after ACLR with a PLT autograft.

A paucity of evidence regarding radiographic follow-up of ACLR with a PLT autograft was also found. A single case series of 18 patients by Zhai et al46 revealed no tunnel enlargement from the third month to the final 2-year follow-up after ACLR with a PLT autograft combined with bone morphogenetic proteins and allogeneic bone.

Anterior knee pain and kneeling pain are common complications following PT and HT autograft harvesting. Although significantly more frequent after PT harvesting (52% and 63%, respectively) as compared with HT (17% and 35%, respectively) at 2-year follow-up, anterior knee pain and kneeling pain are comparable at 15-year follow-up.48 Surprisingly, none of the included studies assessed anterior knee pain as an outcome measure after ACLR with a PLT graft. Therefore, there is no evidence to support its use over HT graft since it cannot be determined whether anterior knee pain results from the ACLR
procedure itself or from the implemented graft. In addition, the only comparative study assessing PLT versus HT grafts in simultaneous ACL and MCL injury failed to prove superior medial stability over groups after ACLR and MCL repair.

Regarding donor-site morbidity from harvesting the PLT, results may vary among patients. The tendon’s main functions are plantar-flexion and evasion of the foot, while it also acts as a dynamic stabiliser for the ankle and foot.40 Although the main insertion of the PLT is at the base of the first metatarsal, anatomical studies have shown wide variations in this pattern, where the tendon spans multiple slips inserting at the medial cuneiform, the plantar aspects of the second through fifth metatarsals, and the first dorsal interosseous muscle.50 51 The functional implications of these variations may affect the dynamic stability of the mid-foot and forefoot, and especially the first tarsometatarsal joint, leading to instability of the medial column and a metatarsus primus varus deformity.52 The long-term effect of this dynamic instability on foot and ankle function remains an area of concern.

There are several clinical studies following donor-site morbidity from PLT harvesting. There exists conflicting evidence regarding its effect on the ankle eversion and first ray plantar flexion. Weakness in eversion is partially compensated by the relatively stronger action of the peroneus brevis.13 54 Some studies have shown significant differences in strength between operated and non-operated sides,6 16 21 whereas others have not.8 9 30 Spatio-temporal gait parameters between the two sides have also been studied. Nazem et al28 and Karimi et al29 found no significant differences in stride length, speed or cadence. However, the latter study demonstrated an increase in the inversion/eversion and rotation of the operated ankle, with a significant increase in its rotatory moment.29 When interpreting data from published studies, one also needs to be aware of the alternative option to use only half of the tendon width as a graft.12 22 23 36 Conclusions drawn from these studies cannot be extrapolated to the scenario of harvesting the whole PLT.

Neurological complications, such as paresthesia and dysesthesia around the lateral ankle, may also occur and can be attributed to the proximity and anatomical variations in the course of the sural and superficial peroneal nerves. One study27 reported these in 6.9% of cases.

In several studies, donor-site morbidity was assessed using non-validated and general functional scores, such as the AOFAS and FADI.8 16 33 34 38 36 Although favourable with respect to overall ankle function, results should be interpreted with caution due to the inherent weaknesses of these scores. Interestingly, the potential for peroneus longus stump regeneration after grafting has been demonstrated in postoperative MRI studies.16 37–39 The introduction of new validated tools for the subjective and objective evaluation of ankle function, such as the PROMIS score,38 will likely enable researchers to assess donor-site morbidity in a more accurate manner in future studies.

Regarding graft dimensions, the relationship between HT graft size and the rate of ACL revision surgery has been the subject of debate in recent years. The mean graft diameter of four-strand HT ranged from 7.7 to 8.5 mm.50–61 Most of the studies attempting to find a relationship between the diameter of the graft and the failure rate have proven that size matters.62–69 Interpreting these reports, some authors have concluded that choosing a graft size of 8.5 mm or larger can reduce the incidence of failure. Every increase of 0.5 up to 10 mm seems to provide additional stability. Nevertheless, it remains unclear whether selecting a graft larger than 10 mm would be beneficial for patients.70

Therefore, it is also important to know the expected size of the PLT autograft. We also found variability in the reported graft size of the PLT, but it was similar to that of the HT grafts. The sizes also ranged from 7.0 to 8.8 mm, depending on the graft preparation technique. AHPLT grafts were usually no greater than 8.1 mm. Further comparative studies are needed to characterise the advantages of selecting PLT or AHPLT grafts with respect to the rate of re-rupture and donor ankle morbidity.

Similar to the HT, anthropometric measurements influence the tendon graft size.13 39–40 60 69 71–74 Consequently, these measurements should also be considered during preoperative planning and prediction of the PLT length and diameter. Quadriceps tendon-patellar bone grafts have a potential advantage in graft size over HT and PLT since the available area to harvest the graft is larger.5–77

The present study has several limitations. First, there is high variability among ACLR and PLT graft preparation techniques. Second, the included studies report outcomes over a follow-up period no longer than 2 years. Third, the lack of objective measurements of graft-donor ankle morbidity hinders any recommendations regarding the safety of harvesting. Finally, it should be mentioned that all studies reported in our investigation were carried out in Asian populations; hence, variability in populations must be considered when interpreting our results regarding tendon dimensions.78–82

CONCLUSIONS

In light of the current findings, the clinical and stability outcomes of ACLR with different PLT autograft preparation techniques are comparable with those of HT during short-term follow-up. However, there is insufficient evidence to support its use in the kneeling populations or in patients with simultaneous ACL and MCL injury. Thus, stronger evidence generated using validated tools reporting negligible donor-graft ankle morbidity after PLT harvesting is needed prior to recommending its routine use, despite the consistency of its dimensions.

Future investigations should aim to prove the potential benefits of PLT in ACLR, evaluating anterior knee pain over other graft options and medial stability in the concurrent MCL injury through RCTs. Moreover, the evaluation of donor-graft ankle morbidity using objective parameters and validated tools should be of paramount importance with a view to further recommending the implementation of this autograft in orthopaedic procedures.

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