ABSTRACT

Introduction: Anterior cruciate ligament injury is one of the most prevalent musculoskeletal injuries. Therefore, several surgical techniques and graft types have been described for its reconstruction. Autologous hamstring tendon graft is one of the most frequently used, but use of the quadriceps tendon graft has gained prominence in recent years. Objective: To review the literature to compare the outcomes of patients undergoing anterior cruciate ligament reconstruction (ACLR) with quadriceps tendon (QT) autograft versus hamstring tendon (HT) autograft. Methods: A literature review was conducted through PubMed to locate studies (Level of evidence I-III) comparing the outcomes of the QT autograft vs. the HT autograft in patients undergoing primary ACL reconstruction. Patients were assessed on the basis of re-rupture rate, ligament instability, patient-reported outcome scores, previous pain, and isokinetic tests. Results: Six studies were selected according to inclusion criteria. A total of 481 patients were evaluated, 243 in the QT group and 238 in the HT group. The total re-rupture rate was 1.6% (8 of 481), with 6 in the HT group and 2 in the QT group, but with no statistical difference between groups. One study found increased ligament instability in the HT group and another study found greater instability in the QT group, both with statistical significance. Regarding the patient-reported functional scores, only one study found statistical difference, with better results in the QT group. There was no difference in previous pain between groups in the selected studies. Regarding the isokinetic test, one study found a difference in flexor force in the HT group (p <0.01), with no difference in extensor force, while another two studies found an increased extensor force deficit in the QT group within up to one year of follow-up. The flexor/ extensor muscle strength ratio was higher in the QT group in both studies. Conclusion: ACL reconstruction with QT graft presents re-rupture rates, ligament instability, functional scores and donor site morbidity that are similar to the HT graft, in addition to preserving greater flexor force in proportion to extensor force. Level of evidence: IV; Review study.

Keywords: Anterior cruciate ligament reconstruction; Quadriceps muscle; Hamstring tendons; Transplantation, autologous.
INTRODUCTION

Anterior cruciate ligament (ACL) injury is one of the most prevalent musculoskeletal injuries.\(^1\) Arthroscopic ACL reconstruction has been described since the 80s,\(^2\) and the discussion regarding graft choice continues. Patellar tendon (PT) graft was initially considered the gold standard in ACL reconstruction.\(^3,4\) After the hamstring tendon (HT) graft became popular, several studies appeared comparing these two grafts. The use of the HT involves lower donor site morbidity,\(^5\) and some studies\(^6,7\) have noted that both entail similar clinical outcomes. However, there are reports of a higher rate of re-rupture and ligament instability in patients undergoing ACL reconstruction with HT.\(^8,9\)

The quadriceps tendon (QT) graft was initially described by Marshall in 1979,\(^10\) while Blauth\(^11\) described the use of the midthird quadriceps tendon with patellar bone block in 1984. In 1999, Fulkerson et al.\(^12\) reviewed this surgical technique by not using bone block, aiming at reducing donor site morbidity and other complications. However, this graft is one of the least used in comparison to HT and PT.\(^13\)

The focus on ligament reconstruction with autologous QT graft recently made a comeback. There are some studies in the literature comparing QT and PT grafts in ACL reconstruction. It is possible to find similar clinical outcome and rate of complications between the two groups, with the advantage of lower donor site morbidity in the QT group.\(^16-20\)

Regarding studies comparing HT and QT, data in the literature are scarce,\(^21-26\) particularly on comparative studies. The aim of this study is to perform a literature review comparing the clinical outcomes of patients undergoing anterior cruciate ligament reconstruction with QT versus HT.

MATERIALS AND METHODS

A literature review was performed and two independent reviewers undertook searches in PubMed up to the 31st of July, 2018. The keywords sought were: “anterior cruciate ligament” and “quadriceps muscle”.

A total of 833 studies was reviewed by title and abstract. Inclusion criteria were studies that directly compared clinical outcomes in ACL reconstruction with QT and HT (evidence level I-III) and studies in English. Non-comparative studies or those without an available abstract were excluded. Six studies were selected according to the applied criteria. These studies were not uniform in terms of surgical technique and rehabilitation protocol applied, and will be described in the results.

RESULTS

Six studies (level of evidence III) met the inclusion and exclusion criteria, with a total of 243 patients undergoing ACL reconstruction with QT and 238 with HT. The mean follow-up time between studies was 27.4 months (ranging from 12 months to 48 months). There was no significant difference between the cohorts in terms of age, sex, concomitant cartilage injuries or other characteristics in most of the studies included with the exception of Fischer et al.,\(^23\) in which there was a higher proportion of male patients undergoing reconstruction with HT. The characteristics of the studies and demographic data are described in Table 1.

Surgical technique

Removal of Quadriceps Graft. The studies were not uniform in terms of the graft removal method and use of bone plug. Only one study\(^24\) used a minimally invasive technique for graft removal with a suprapatellar transverse incision, while the others used a longitudinal route in the topography of the QT. Most studies used bone plug, except for Martin-Alguacil et al.\(^25\)
Removal of Hamstring Graft. Two studies did not describe the HT graft removal method. One study describes removal with a vertical incision in the anteromedial aspect of the tibia over the goose foot (aka pes anserinus), and removal of the graft with an open stripper, maintaining Tibial fixation. The other studies used an oblique incision in the goose foot topography and removal of the grafts with a closed stripper.

Preparation of the tunnels and graft fixation. To create the femoral tunnel, two studies\(^{21,22}\) used the transtibial technique, three studies\(^{23,25,26}\) opted for the anteromedial portal at the anatomical point, and one of these\(^{24}\) applied the outside in technique. The creation of the Tibial tunnel, which was similar between groups, was performed at the native site of the ACL, medial to the lateral meniscus root and lateral to the medial Tibial spine. Only one study did not use a bone plug.\(^{26}\) In addition, only one of the studies evaluated did not use the same surgical technique as the control group;\(^{22}\) since single-bundle ACLR was performed in the QT group and double-bundle ACLR in the HT group. Graft fixation is described in Table 2.

Postoperative rehabilitation. Three of the studies\(^{22,23,25}\) used a hinged brace from two to six weeks postoperatively. Return to sports was described in only two studies, one within six months\(^{21}\) and the other according to the hop test and muscle strength. Only one study did not describe the rehabilitation protocol.

Donor site morbidity. Four studies\(^{21-24}\) evaluated morbidity in relation to the donor site of the graft used. In this case, the presence of previous pain was evaluated. None of the studies found differences between groups.

Re-rupture rate. Three studies\(^{23,24,26}\) evaluated the presence of graft failure in the follow-up performed. None of the studies found a significant difference in the re-rupture rate between groups, yet Martin-Alguacil et al.\(^{26}\) discovered an increased tendency for re-rupture in the HT group and from 0% to 3.8% in the QT group (Table 3).

Table 3. Falha Enxerto.

<table>
<thead>
<tr>
<th>Authors</th>
<th>TQ</th>
<th>TF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavaignac et al. 2017(^{24})</td>
<td>1/45 (2.2%)</td>
<td>2/41 (4.8%)</td>
<td>3 (3.4%)</td>
</tr>
<tr>
<td>Runer et al. 2017(^{22})</td>
<td>0/40(0%)</td>
<td>1/40 (2.5%)</td>
<td>1 (1.2%)</td>
</tr>
<tr>
<td>Martin-Alguacil et al. 2018(^{26})</td>
<td>1/26 (3.8%)</td>
<td>3/25 (12%)</td>
<td>4 (7.8%)</td>
</tr>
</tbody>
</table>

Table 4. Frouxidão anteroposterior.

<table>
<thead>
<tr>
<th>Authors</th>
<th>TQ</th>
<th>TF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavaignac et al. 2017(^{24})</td>
<td>1.1 +/-0.9</td>
<td>3.1 +/-1.3</td>
<td>0.037</td>
</tr>
<tr>
<td>Lee et al 2016(^{22})</td>
<td>2.1 +/-1.9</td>
<td>19 +/- 1.8</td>
<td>0.32</td>
</tr>
<tr>
<td>Soto et al 2013(^{21})</td>
<td>5.6</td>
<td>3.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Martin-Alguacil et al. 2018(^{26})</td>
<td>3.3</td>
<td>3.1</td>
<td>0.719</td>
</tr>
</tbody>
</table>

Four studies\(^{21-24}\) evaluated clinical outcomes between the evaluated groups. All studies used the Lysholm score (Table 5), and only Cavaignac et al.\(^{24}\) found statistical difference with better functional result in the QT group (P<0.05). Three\(^{22,24,26}\) studies evaluated the presence of graft failure in the follow-up performed. None of the studies found a significant difference in the re-rupture rate between groups, yet Martin-Alguacil et al.\(^{26}\) discovered an increased tendency for re-rupture in the HT group and from 0% to 3.8% in the QT group.

Table 1. Características dos estudos e características demográficas dos pacientes do grupo TF versus TQ.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Evidence level</th>
<th>n</th>
<th>Age, years</th>
<th>H/M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavaignac et al. 2017(^{24})</td>
<td>III</td>
<td>45</td>
<td>41</td>
<td>32.1 +/-8</td>
</tr>
<tr>
<td>Fischer et al. 2017(^{23})</td>
<td>III</td>
<td>61</td>
<td>61</td>
<td>21.7 +/-7.4</td>
</tr>
<tr>
<td>Runer et al. 2017(^{21})</td>
<td>III</td>
<td>40</td>
<td>40</td>
<td>34.6 +/-11.0</td>
</tr>
<tr>
<td>Martin-Alguacil et al. 2018(^{26})</td>
<td>III</td>
<td>26</td>
<td>25</td>
<td>18.7 +/-3.6</td>
</tr>
<tr>
<td>Lee et al. 2016(^{22})</td>
<td>III</td>
<td>48</td>
<td>48</td>
<td>31.1 +/10.0</td>
</tr>
<tr>
<td>Soto et al. 2013(^{21})</td>
<td>III</td>
<td>23</td>
<td>21</td>
<td>26.8</td>
</tr>
</tbody>
</table>

Table 2. Características das técnicas cirúrgicas do grupo TQ e TF.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Technique</th>
<th>FF</th>
<th>FT</th>
<th>PO</th>
<th>TF</th>
<th>Technique</th>
<th>FF</th>
<th>FT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavaignac et al. 2017(^{24})</td>
<td>A - outside in</td>
<td>PA</td>
<td>PA</td>
<td>com, tibia</td>
<td>A - outside in</td>
<td>PA</td>
<td>PA</td>
<td></td>
</tr>
<tr>
<td>Fischer et al. 2017(^{23})</td>
<td>A - AM</td>
<td>BE</td>
<td>PA</td>
<td>com, tibia</td>
<td>A - AM</td>
<td>BE</td>
<td>PA</td>
<td></td>
</tr>
<tr>
<td>Runer et al. 2017(^{22})</td>
<td>A - AM</td>
<td>BE</td>
<td>PA + Endotack</td>
<td>com, fêmur</td>
<td>A - AM</td>
<td>BE</td>
<td>PA + ponto transósseo</td>
<td></td>
</tr>
<tr>
<td>Martin-Alguacil et al. 2018(^{26})</td>
<td>A - AM</td>
<td>BE</td>
<td>PA</td>
<td>com, fêmur</td>
<td>A - AM</td>
<td>BE</td>
<td>PA</td>
<td></td>
</tr>
<tr>
<td>Lee et al. 2016(^{21})</td>
<td>Transtibial</td>
<td>PM</td>
<td>PA</td>
<td>com, fêmur</td>
<td>A - DB</td>
<td>BE</td>
<td>PA</td>
<td></td>
</tr>
<tr>
<td>Soto et al. 2013(^{21})</td>
<td>Transtibial</td>
<td>PM</td>
<td>PA</td>
<td>com, fêmur</td>
<td>Transtibial</td>
<td>Transfemoral</td>
<td>PA</td>
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</tbody>
</table>

DISCUSSION

The choice of graft in ACL reconstruction is a pertinent and persistent topic of conversation among orthopedists, and different types of graft and clinical outcomes have been described in the literature. The focus on the use of the quadriceps grafts has recently made a comeback. This was initially described by Marshall in 1987, and later modified by not using patellar bone plug by Fulkerson in 1999. Despite this modification, only one of the studies evaluated did not use bone plug.

Some series in the literature describe good results with the use of quadriceps grafts. Guimaraes et al., in a series of patients with a mean follow-up of 10 years, found good results in functional scores, return to sports and donor site morbidity. Chen et al., in a series with a mean follow-up of four to seven years, also found satisfactory subjective and objective clinical outcomes and discovered that loss of extensor force was minimal. However, there are few studies comparing QT grafts with other grafts. What we found were subjective clinical outcomes and a similar rate of re-rupture in the QT group and HT groups, with the exception of two authors. Sofu et al., found increased ligament stability in the HT group. The author attributes this to an increase in biomechanical stress on the reconstructed graft by decreasing the strength and diameter of the remaining quadriceps tendon. This is contradictory in the literature because Adams et al., found greater force in the donor graft and remaining quadriceps tendon when compared with patellar tendon graft. One of the factors that may explain this difference is that Sofu et al., did not use the same fixation technique for both groups evaluated, and applied the transatlantical technique in ligament reconstruction. In the study described by Cavaignac et al., functional scores and ligament stability were higher in the QT group, with no deterioration in donor site morbidity.

Diminished muscle strength after ACL reconstruction is associated with a higher risk of knee injury, and recovery of this muscle strength is vital when resuming sport activities. Activation of the hamstring muscles is known to reduce stress on the reconstructed graft. Therefore, its preservation may decrease the rate of re-rupture after ACL reconstruction. One of the criteria for resumption of sport activities is 80% to 90% extensor force compared to the contralateral side.

However, the flexor/extensor force ratio is just as important as absolute strength. A ratio of 50% to 80% is considered ideal when resuming sport activities. Moreover, it is affirmed in the literature that a ratio above 100% is a protective factor for ACL injury. Three conducted isokinetic tests during postoperative follow-up. Lee et al., found greater and faster flexor force recovery in the QT group, with no difference in extensor force, but the same author did not describe the flexor/extensor force ratio. Martin-Alguacil et al., and Fischer et al., found a better flexor/extensor force ratio in the QT group up to one year of follow-up, but both authors found lower extensor force in this group. These findings suggest that the use of quadriceps grafts, despite violating the extensor mechanism with a decrease in its strength, preserves flexor force. This can be advantageous in ACL reconstruction, especially in the first months after surgery.

The use of quadriceps grafts has promising results with good long-term clinical outcomes and low donor site morbidity. However, there are reports in the literature of complications in QT graft removal, ranging from patellar fracture and excessive bleeding when the graft comes into contact with perforating vessels of the quadriceps muscles, to cosmetic deformities with femoral muscle retraction.

There are some limitations to this study. Only six comparative studies are available in the literature with level of evidence III, and these were not consistent in terms of the surgical technique employed.

CONCLUSION

ACL reconstruction with QT graft has similar re-rupture rates, ligament instability, functional scores and donor site morbidity as the HT graft, besides preserving greater flexor force proportional to extensor force.

All authors declare no potential conflict of interest related to this article.

AUTHORS’ CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. VERS, DEO: were the main contributors in the writing of the manuscript; MVL, ADJ, LGGB, RPLC, PBJ: performed the literature search, reviewed the manuscript, and contributed to the intellectual concept of the study. All authors participated and approved the final version of the manuscript.

REFERENCES


