Acta Orthopaedica et Traumatologica Turcica 53 (2019) 180–183

Contents lists available at ScienceDirect

Acta Orthopaedica et Traumatologica Turcica

journal homepage: https://www.elsevier.com/locate/aott

Clinical outcomes after ACL reconstruction with free quadriceps tendon autograft versus hamstring tendons autograft. A retrospective study with a minimal follow-up two years

Adrian Todor*, [1], Dan Viorel Nistor, Sergiu Caterev

Department of Orthopaedics, Traumatology and Paediatric Orthopaedics, "Iuliu Hatieganu" University of Medicine and Pharmacy, Napoca, Romania

ARTICLE INFO

Article history:
Received 28 December 2017
Received in revised form
5 September 2018
Accepted 3 March 2019
Available online 21 March 2019

Keywords:
ACL reconstruction
Quadriceps graft
Hamstring graft
Single bundle
Clinical outcome

ABSTRACT

Objective: The aim of this retrospective study was to compare the clinical outcomes of anatomic single bundle ACL reconstruction using either a free quadriceps tendon autograft or a quadrupled hamstring autograft with a minimum follow-up of 24 months.

Methods: Consecutive patients undergoing ACL reconstruction using either a free quadriceps tendon autograft or hamstring tendon autograft from January 2013 to December 2014 were included. ACL reconstruction was done in all patients due to isolated ACL tears. Patients with associated cartilage lesions > Outerbridge III, meniscal lesions in need of meniscectomy or repair as well as patients with prior knee surgery on the affected or contralateral knee were excluded. The primary outcome evaluation was the side-to-side difference in instrumented Lachman testing. Secondary outcome evaluation consisted in the Lysholm, modified Cincinnati and SF-36 scores. Side-to-side difference in range of motion and thigh diameter was also documented.

Results: After applying the inclusion/exclusion criteria, a total of 82 patients were identified and 72 (87.8%) presented to the hospital for follow-up. There were 39 patients with quadriceps graft (30.64 ± 8.71, range: 18–53 years) and 33 patients with hamstrings (28.60 ± 6.74, range: 18–46 years). No statistically significant difference between groups was detected with regard to KT-1000 measurements ($p = 0.326$). No significant difference was found between the mean postoperative Lysholm ($p = 0.299$), the modified Cincinnati ($p = 0.665$) and the general SF-36 scores between groups ($p = 0.588$). Less side-to-side thigh diameter difference was noted in the quadriceps graft group ($p = 0.026$).

Conclusion: In conclusion, similar clinical results, in terms of stability and subjective measures, can be obtained after ACL reconstruction both with a free quadriceps and a 4-strand hamstring tendons autograft.

Level of evidence: Level III, Therapeutic Study.

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Introduction

The most commonly used autograft for ACL reconstruction is hamstring tendon (HT) autograft,[1] followed by bone-patellar tendon-bone (BTB) autograft.[2–4] Both graft choices have pros and cons, as there is no clear evidence of one's superiority over the other.[5–7] However, with regard to graft associated morbidity, HT are recognized as providing less donor site morbidity compared to BTB grafts.[8–10]

Recently, there has been an increased interest in the use of quadriceps tendon (QT) as an autologous graft option for ACL reconstruction.[11,12] This increased interest might be due to the development of graft harvesting technique, for which less invasive techniques with smaller incisions have been introduced.[13] However, although QT as graft for ACL reconstruction is known for a long

* Corresponding author. Tel.: +40 744757002.
E-mail addresses: adi.todor@yahoo.com (A. Todor), dan88nistor@yahoo.com (D.V. Nistor), caterevsergiu@gmail.com (S. Caterev).

Peer review under responsibility of Turkish Association of Orthopaedics and Traumatology.

[1] Home address: 15 Aviator Badescu street, 400196, Cluj Napoca, Romania.

https://doi.org/10.1016/j.aott.2019.03.004
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time and favorable results have been reported, it is still only considered as a second-line option for primary ACL reconstruction.[14,15] Some studies even outline less donor site morbidity after QT ACL reconstruction than after BTB ACL reconstruction.[11] Moreover, donor site morbidity for the free quadriceps graft without a patellar bone block was shown to be even lower than with HT graft harvest.[16]

Other major conceptual advantages of QT autografts are well predictable size, a great versatility and the ability to harvest grafts in different widths, thicknesses, and lengths.[12,13,17,18] Also, graft maturity has been shown to be better at 6 month following ACL reconstruction with QT compared to HT autograft, although a bone-QT graft was used in this study.[19] However, there is only scarce data comparing clinical outcomes in patients who underwent ACL reconstruction using a free QT autograft or HT autografts.

The purpose of this study was to compare the clinical outcomes of patients undergoing anatomic single bundle (SB) ACL reconstruction using either a free QT autograft or a quadrupled HT autograft with a minimum follow-up of 24 months. Our hypothesis was that the results would be comparable between the two groups.

Methods

In this retrospective study, consecutive patients undergoing ACL reconstruction using either a free QT autograft or HT (Gracilis and Semitendinosis) autograft from January 2013 to December 2014 were included. ACL reconstruction was done by a single surgeon (AT) using an identical fixation technique. All patients were identified via hospital database. All operative data and diagnosis was collected from the patient's charts including demographics, primary and secondary diagnosis, operative report and followup data.

Patients with associated cartilage lesions > Outerbridge III (n = 14), meniscal lesions in need of meniscectomy (n = 21) or repair (n = 11), multiligamentous lesions (n = 3) as well as patients with prior knee surgery on the affected or contralateral knee were excluded (n = 11).

An identical surgical technique was used in all cases except for the graft harvest. An arthroscopic anatomic SB ACL reconstruction was done using a three portal technique.[20] The femoral tunnel was drilled through the anteromedial portal while viewing from the central portal with the knee hyperflexed. The tibial tunnel was created while viewing from the anterolateral portal and the guide set at 50° introduced through the anteromedial portal. Both tunnels were drilled with the same diameter as the graft. No tunnel dilatation was used. Femoral fixation was achieved by extra-cortical non-adjustable loop button (XO Button - ConMed Linvatec, Largo, FL). The length of the loop was calculated to provide from 1 to 2 cm in the femoral tunnel, the vast majority being a 15 mm loop device. Tibial fixation was done using a bioabsorbable interference screw (Genesys Matryx, ConMed Linvatec), same diameter as tunnel size. No other back-up fixation was used.

The free QT was harvested via a longitudinal 4 cm skin incision proximal to the patella. The distal part of the tendon was released from the patellar insertion and two no. 2 high strength polyethylene sutures were whipstitched to this end of the graft. On the back table the suspensory button was attached by suturing the previously placed high strength polyethylene wires through the button's loop[12] (Fig. 1). The HT graft was harvested in the usual manner through a 3 cm antero-medial tibial vertical incision with a closed tendon stripper and a 4 stranded construct was fashioned using both the Gracilis and the Semitendinosus tendons.

All patients underwent an identical postoperative protocol. None of the patients was bearing a brace postoperatively. Partial weight bearing with crutches was done for a period of four weeks. From four weeks on full weight bearing was allowed. Stationary bicycle was recommended from six weeks on, running on a treadmill, as well as swimming was allowed from three months on. Sports activities requiring pivoting actions was allowed from nine months postoperatively.

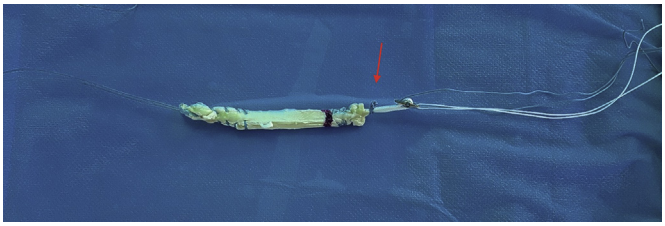

Fig. 1. Free quadriceps graft on the preparation table. The extracortical button for femoral fixation is attached with the use of high-strength sutures (arrow).

All patients identified via hospital database were contacted by telephone and a follow-up visit was scheduled. After signing the informed consent, a clinical examination was conducted and patients were instructed to complete a set of evaluation forms. KT-1000 arthrometer (KT-1000, MEDmetric Corporation, San Diego, CA) was used for assessment of anterior laxity measurement at Lachman test. Muscle atrophy was assessed by measuring the diameter of the thigh at a point 12 cm proximal to the patella in full extension with the muscles relaxed. The evaluation forms used were the modified Cincinnati score,[21] Lysholm knee scoring scale[22] and SF-36 Health Survey. In addition, adverse events such as ACL failure, arthrofibrosis, as well as need for and type of revision surgery was noted. Graft diameter was noted for each case, and for the quadriceps group, length of the graft was also documented. Graft failure was defined when a side-to-side difference in Lachman testing was more than 3 mm, as compared to the uninjured side, if there was a documented tear of the graft by MRI or if there was a subsequent arthroscopic procedure that documented the graft as being ruptured.

Ethical approval was obtained from the institution's ethical committee (373/14.10.2016). All procedures performed were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Statistics

To determine the normality of the distribution of each variable the Shapiro–Wilk test was used. The Student t-test for independent sample was applied when comparing normal distributed continuous data. For non-normally distributed or ordinal variables, the Mann–Whitney U test was used and reported as median and Q1 and Q3 quartiles. A Pearson Chi-square test or Fisher exact test were performed to compare dichotomous data, and are reported as frequency and percentage.

Statistical significance was established at $p < 0.05$ with 95% confidence intervals.

A power analysis was done with the primary outcome of instrumented laxity values at Lachman test. In a comparable study investigating the instrumented laxity in patients after ACL reconstruction using QT graft or patellar tendon autograft Lund et al[23] calculated a sample size of 24 patients per group with a power of 80%. Hence, the power analysis was reassessed and delivered a similar sample size.

All electronic data collected from multiple computers in the hospital network was than gathered and organized with the support of the University's Department of Medical Informatics and Biostatistics, together with their data management systems.[24,25]

Results

In the mentioned time-frame a total of 142 ACL reconstructions were performed by the senior surgeon. After applying the inclusion/exclusion criteria, 82 patients were identified and contacted. A total of 72 patients (87.8%) responded and presented to the hospital for a follow-up visit. There were 39 patients with quadriceps graft and 33 patients with hamstrings. The demographic data was very similar between groups and is presented in Table 1. The mean followup period was 34.45 ± 6.51 (24–45) months for the HT group and 33.76 ± 6.63 (24–46) months for the QT group.

There were no statistically significant differences between the two groups with regard to instrumented Lachman testing, ROM, modified Cincinnati, Lysholm and SF-36 scores. The data is presented in Table 2. The only difference between groups, with a statistical significance was, the side-to-side thigh diameter difference. The operated limb had a thinner thigh with a mean 0.43 ± 1.68 cm in the QT group and a mean 1.33 ± 1.65 cm in the HT group ($p = 0.026$).

For the QT group the mean graft diameter was 8.57 ± 0.56 (7.5–10) mm on the femoral side and 9.03 ± 0.63 (8–11) mm on the tibial side. In the HT group the grafts had a mean diameter of 7.65 ± 0.6 (7–9) mm on the femur and 8.04 ± 0.51 (7–9) mm on the tibial side. The mean length of the free quadriceps graft was 8.97 ± 0.58 (7.5–10) cm.

In both groups, there were no readmissions or re-operations for complications. There was one patient, in the QT group, with a side-to-side difference of 5 mm on KT-1000 testing and was considered as failure. No patients in the HT group had a difference of more than 3 mm.

5 patients in the QT group (12.82%) reported unsatisfactory cosmetic appearance of the supra patellar incision and 8 patients in the HT group (24.24%) reported mild numbness on the antero-medial aspect of the leg.

Discussion

The principal findings of this study show that similar results, in terms of stability and patient reported outcomes, can be obtained both with a HT or a free QT autograft, confirming our hypothesis. We found no statistically significant difference related to instrumented laxity testing, Lysholm, modified Cincinnati, SF-36 scores and ROM between groups.

This study clinically validates the use of a free QT graft fixed on the femur with an extra-cortical button attached to the graft with high strength sutures, technique previously described in the literature.[12] A recent study by Runer et al[26] showed similar results, with no difference between QT and HT autografts in patients with ACL reconstruction at 2 year follow-up. However, the authors used bone-QT grafts. Another study, by Cavaignac et al[27] showed equal or better functional outcomes with bone quadriceps graft compared to hamstrings graft more than 3 years after ACL reconstruction. Using a free QT graft can minimize donor site morbidity without compromising the results. Overall, donor site morbidity has been found to be minimal with the quadriceps graft, both with a normal or minimally invasive harvesting technique.[11,16,28]

Still, the QT is the least used graft for primary ACL reconstruction, with about 10% of the reconstructions being performed with a quadriceps graft.[27,29] It is expected that the use of this graft will be increasing in the future[30] as data shows good anatomical and biomechanical characteristics to the QT graft.[26,31,32] Also, studies have shown good clinical results with QT graft compared to patellar tendon graft, still considered gold standard by some authors. Lund et al found comparable results in a prospective randomized trial comparing QT with patellar tendon. However, knee walking pain was significantly less for QT than with BTB.[23] Similar results were reported by others.[26] In a systematic review by Slone et al, which included 14 studies of which 6 compared QT grafts versus BTB grafts, there were similar results regarding laxity, functional outcomes, overall patient satisfaction, range of motion (ROM), and complications between QT and other graft options.[11] A recent article by Belk et al reported less knee laxity in patients with QT ACL reconstruction compared to HT patients but with no difference in failure rates between groups.[33] Other advantages may be attributed to the quadriceps graft. A study, based on magnetic resonance imaging, by Ma et al showed that graft maturity was better at 6 month following ACL reconstruction with QT compared to HT autograft.[19]

Another important aspect related to graft choice is muscle recovery. In our groups of patients there was a statistically significant difference with less thigh muscle atrophy in the QT group compared to the HT group ($p = 0.026$). However, muscle recovery was not evaluated in terms of strength and there were no data on pre-operative thigh dimensions. The measurements were performed at the final follow-up and compared to the un-injured side. Iriuchishima et al[28] showed similar level of muscle recovery after ACL reconstruction with QT compared to previously reported data with HT autografts. Fischer et al[34] comparing muscle strength after ACL reconstruction with quadriceps graft versus hamstrings, reported a statistically significant lower knee extensor strength and greater flexor muscle strength in the QT group compared to HT group. Also, a higher H/Q ratio was found in patients with QT grafts within the first months following surgery.

The study has several limitations to be considered. First, it is a retrospective study with the documented clinical examination at the last follow-up and no patient reported scores or KT-1000 measurements were obtained preoperatively. Also, the person which collected the data was not blinded to the graft used. Furthermore the graft choice was not randomized, the decision was made by the operating surgeon after discussing with the patients.

The strengths to be noted with the study are the homogeneity of the groups in terms of demographics and the fact that pure ACL reconstructions were selected, without associated meniscal or cartilage procedures that could have influenced the outcomes and that the same surgical technique was used throughout the study and by the same operating surgeon.

Table 1
Demographic data for patients included in the study and the follow-up period.

	Quadriceps (n = 39)	Hamstring (n = 33)	p-value
Age (yrs)[a]	30.64 ± 8.71 (18–53)	28.60 ± 6.74 (18–46)	0.278
BMI (kg/m^2)[a]	25.17 ± 4.38 (18.52–37.58)	25.21 ± 2.92 (18.34–30.93)	0.964
Gender (female)[b]	13 (33.3)	10 (30.3)	0.783
Laterality (right)[b]	23 (59.0)	17 (51.5)	0.525
Follow-up (months)[a]	33.76 ± 6.63 (24–46)	34.45 ± 6.51 (24–45)	0.661

BMI = body mass index.
[a] Mean ± standard deviation (range); Student t-test for independent sample.
[b] No, (%); Chi-square test or Fisher exact test.

Table 2
Summary of clinical outcomes of patients with ACL reconstruction with a quadriceps graft and with 4-strand hamstring autograft.

	Quadriceps (n = 39)	Hamstring (n = 33)	p-value
Side-to-side difference ROM flexion (degrees)[b]	0 (0;2)	0 (0;5)	0.337
Side-to-side difference ROM extension (degrees)[a]	−1.23 ± 2.57	−0.75 ± 2.23	0.412
Side-to-side difference Lachman (mm)[b]	1 (0; 2)	1 (0; 1)	0.326
Side-to-side difference thigh diameter (cm)[a]	0.43 ± 1.68	1.33 ± 1.65	0.026[c]
Lysholm score[a]	89.20 ± 9.97	91.33 ± 6.65	0.299
Cincinnati score[a]	92.15 ± 9.03	93.00 ± 7.20	0.665
SF-36 General[a]	80.25 ± 15.12	82.12 ± 13.75	0.588

ROM = range of motion.
[a] Mean ± standard deviation; Student t-test for independent sample.
[b] Median (Q1; Q3), where Q = quartile; Mann–Whitney test.
[c] Statistical significant difference.

Conclusions

Similar clinical results, in terms of stability and subjective measures, can be obtained after ACL reconstruction both with a free quadriceps and a 4-strand hamstring tendons autograft. In our study, there were no statistically significant differences related to instrumented laxity testing, Lysholm, modified Cincinnati, SF-36 scores and ROM between groups.

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