

# EVALUATION OF THE RESULTS OF ARTHROSCOPIC ACL RECONSTRUCTION WITH AUTOGENOUS FLEXOR TENDONS

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## ABSTRACT

*Objective:* To evaluate the results from reconstruction of the anterior cruciate ligament (ACL) using with flexor tendon autografts from the thigh, with analysis on data relating to sex, body mass index (BMI) and associations with lower limb fracture. *Methods:* A group of 265 patients who underwent knee arthroscopy for the purposes of ACL reconstruction using an ipsilateral graft from the flexor tendon of the thigh between July 6, 2000, and November 19, 2007, were evaluated. *Results:* One hundred and seventy-six patients were evaluated over a mean period of  $34.95 \pm 18.8$  months (median: 31 months) (IQR: 20-48 months). The minimum evaluation period was 12 months and the maximum was 87 months. One hundred and thirty-eight patients (78.4%) had excellent results, 22 (12.5%) had good results, eight (4.5%) had fair results and eight (4.5%) had poor results. Higher incidence of good and excellent results for the following categories was not considered to be significant: males ( $p = 0.128$ ), patients with BMI < 25 ( $p = 0.848$ ), or patients with ACL injuries unrelated to an initial traumatic episode of lower-limb fracture ( $p = 0.656$ ). *Conclusion:* The ACL reconstruction technique using tendon autografts from the thigh showed good and excellent results for 91.4% of the sample. Male patients seemed to present a greater tendency towards good and excellent results. No statistically significant difference was found when the results were analyzed in relation to BMI or associations with initial traumatic fracture episodes in the lower limbs.

**Keywords** – Knee; Anterior cruciate ligament; Arthroscopy; Transplantation, autologous

## INTRODUCTION

Over the last three decades, there have been significant changes to the concepts involved in repairs to the anterior cruciate ligament (ACL) of the knee, particularly in relation to choosing the graft to be used in the procedure<sup>(1-4)</sup>. Authors such as Shelbourne and Aglietti published results showing the efficacy of patellar tendon grafts as a replacement for the ACL, and for a long time, this technique was considered to be the gold standard for reconstruction of the torn ligament<sup>(1,5-8)</sup>.

The clinical findings from following up cases of ACL reconstruction via the technique of using the middle third of the patellar tendon have demonstrated, in parallel with the good results, persistent pain at the graft donor site, diminished knee extensor mechanism strength and arthrofibrosis, among other complications<sup>(2,7-12)</sup>.

Observation of these complications has led to development of other ACL reconstruction techniques, including the use of grafts from the flexor tendons of the knee (gracilis and semitendinosus)<sup>(1,11,13)</sup>. Large numbers of papers have been published comparing the two techniques and their variants<sup>(2-4,7-9,14,15)</sup>.

The use of the flexor tendon technique has undergone a process of improvement to reach the present-day results. Initially, greater grafting resistance was found, along with some degree of residual weakness at the end of the procedure<sup>(1,8,14)</sup>. The grafting resistance was resolved through using quadruple grafts, and it was found that the fixation methods were responsible for the residual weakness<sup>(2,5,6,16,17)</sup>. Today, the results are seen to be satisfactory and clinically similar to those from the patellar tendon technique<sup>(1,15,16,18)</sup>. Some authors have considered reconstructions using flexor tendons to be

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the gold standard for repairs to knees with a deficient ACL because of the satisfactory final resistance of the graft and the low morbidity of the procedure<sup>(1,3,4,18)</sup>.

The aim of the present study was to evaluate the results from ACL reconstructions using flexor tendon autografts from the thigh, with analysis on data relating to sex, body mass index (BMI) and associations with lower limb fracture<sup>(19)</sup>.

## METHODS

### This was a cross-sectional study.

A group of 265 patients who underwent knee arthroscopy for the purposes of ACL reconstruction using an ipsilateral graft from the flexor tendon of the thigh between July 6, 2000, and November 19, 2007, were evaluated.

The indication for the surgery was a complaint of knee instability in patients with an interest in sports practice or difficulties in undertaking professional activities.

ACL revision procedures were excluded from this study. Patients with any preexisting condition that could compromise the results from the evaluation (muscle loss as a sequela from burns or subastrapagal arthrodesis) and patients in whom any procedure in addition to ACL reconstruction was performed (valgizing tibial osteotomy, posterolateral reconstruction or osteochondroma resection) were also excluded.

The procedure was carried out under anesthesia, by means of subarachnoid block, always by the same surgeon, with the patient positioned in dorsal decubitus and a pneumatic tourniquet applied to the leg. No suction drain was used. A compression bandage was applied after carrying out the surgical procedure, and the patient, the patient's family and the nursing team were instructed to keep the leg completely extended<sup>(20)</sup>.

Continuous cryotherapy was used in all cases over the first 24 hours as an adjuvant method<sup>(21)</sup>.

The scoring system described by Lysholm in 1982 was used to analyze the postoperative result, as follows: excellent results (95-100 points), good (84-94 points), regular (65-83 points) and poor (< 64 points)<sup>(17,22)</sup>.

The variables studied were: sex, age, BMI, Lysholm index result and history of initial trauma relating to leg fracture.

The data were analyzed by means of the SPSS (Statistical Package for the Social Sciences) software, version 15.0 (SPSS Inc. 1989-2006). The results were

presented in the form of means and standard deviations (sd), medians and interquartile range (IQR), frequencies, proportions and the respective 95% confidence intervals (95% CI). The Pearson chi-square test and, when necessary, Fisher's exact test were used to compare frequencies or proportions. Differences with  $p < 0.05$  were considered significant.

## RESULTS

This study evaluated 265 patients, among whom 76 were excluded in accordance with the exclusion criteria, thus leaving a total of  $n = 189$  patients. From these, 13 patients (6.87%) were lost: two who died and 11 who failed to attend follow-ups.

Hence, a total of 176 patients were evaluated over a median period of 31 months (IQR: 20-48 months). The minimum evaluation period was 12 months and the maximum was 87 months.

The mean age was 32.6 years (sd = 10.1). The youngest patient was 13 years of age and the oldest was 54.

In this sample, 131 patients (74.4%) were male. The mean age among the males was 32.4 years (sd = 9.6) and among the females, it was 33.1 years (sd = 11.4). Eighty-one right knees were operated (46%) and 95 left knees (54%).

The patients were classified in accordance with the Lysholm index as excellent, good, regular and poor. There were 138 patients (78.4%) with an excellent result, 22 (12.5%) with a good result, eight (4.5%) with a regular result and eight (4.5%) with a poor result.

In relation to sex, the Lysholm index showed that 122/131 (93.1%; 95% CI: 87.8-96.6) of the male patients and 38/45 (84.4%; 95% CI: 71.6-92.9) of the female patients presented good and excellent results. The difference was not considered to be significant ( $p = 0.128$ ).

In relation to degree of obesity, 81 patients (46%) presented a weight that was considered normal, 65 (36.9%) were overweight, 27 (15.3%) were classified as presenting grade I obesity and three (1.7%) were classified as grade II obesity. There were no patients with morbid obesity in this sample.

Good and excellent results were found in 74/81 patients (91.4%; 95% CI: 83.7-96.1) with BMI that was considered normal (BMI < 25). Upon grouping the patients with BMI > 25 (overweight, grade I obesity and grade II obesity), it was seen that the results were good and excellent in 86/95 patients (90.5%; 95% CI: 82.8-95.6). There was no statistically significant difference in the results between these two groups ( $p = 0.848$ ).

In this sample, 17 patients (9.7%) had ACL injuries relating to an initial traumatic episode, with a leg fracture (tibial plateau fracture, femoral fracture or tibial fracture).

Good and excellent results were found in 15/17 patients (88.2%; 95% CI: 66.3-98.0) with ACL injuries relating to an initial traumatic episode, with a leg fracture. Upon analyzing the remainder of the sample, we found good and excellent results in 145/159 patients (91.2%; 95% CI: 85.7-95.1). There was no statistically significant difference in the results between these two groups ( $p = 0.656$ ).

## DISCUSSION

The incidence of ACL injuries is 0.38 cases for every 1,000 inhabitants, and around 100,000 ACL reconstruction operations are carried out every year in the United States<sup>(3,18)</sup>.

For more than 20 years, use of grafts from the patellar tendon fixed using interference screws was considered to be the gold standard technique for ACL reconstruction<sup>(1,5,7,8)</sup>. However, despite the satisfactory stability conferred<sup>(1,5,6,14,23)</sup>, high morbidity in the graft donor area led to a search for alternative grafts for the procedure<sup>(1,7-11,14)</sup>. The main disadvantages of patellar tendon grafts are: anterior pain in the knee, loss of joint extensor mechanism strength, patellar tendinitis, rupture of the patellar tendon, patellar fracture and arthrofibrosis<sup>(2,7-11,24)</sup>.

The aim of diminishing the morbidity of the procedure led to a progressive increase in the use of flexor tendons as the graft in ACL reconstruction<sup>(13)</sup>. However, their removal is not without morbidity. Flexor tendons provide 30% of the flexion strength of the knee and contribute towards hip extension. Removal of these muscles may cause temporary functional loss, but the range of motion and strength become reestablished through rehabilitation, to levels close to normal<sup>(10)</sup>. Yasuda reported loss of knee flexion only in the first postoperative month<sup>(13)</sup>. The regenerative capacity of the flexor tendons, particularly the semitendinosus, is also reported in the current literature<sup>(23,24)</sup>. However, Burks *et al* did not agree that the loss of strength and retraction were insignificant: they proposed that what was occurring was not regeneration but, rather, invagination of the remaining muscle in the fascia of the gastrocnemius<sup>(23)</sup>.

Investigations in the literature have demonstrated that the ACL reconstruction technique using flexor tendons presents lower morbidity than does the patellar tendon technique.

On the other hand, flexor tendons provide lower stability and resistance to fixation<sup>(1-4)</sup>. This factor emphasized the efficacy and superiority of patellar tendon grafts for many years, since several studies corroborated these results<sup>(1,5,7,11)</sup>. Nevertheless, evolution in the techniques for fixation of flexor tendon grafts and the use of grafts in four bands showed that these previous deficiencies had been overcome<sup>(1,10,15,16,18)</sup>. Since then, papers showing similar efficacy between the two methods have been published<sup>(8,9,14,25)</sup>, and very recently, the performance of the flexor tendon technique has started to outstrip that of patellar tendons<sup>(1-4,10,13,15,18,26-28)</sup>. Prodromos *et al* published two studies, of which one was a meta-analysis, in which possible reasons why the patellar tendon technique had erroneously presented better results over the years were identified. As a first hypothesis, they suggested that most studies had compared patellar tendons with flexor tendons in two bands rather than in four bands, which conferred greater resistance and a greater area for revascularization and nutrition through diffusion<sup>(1,15)</sup>. As a second hypothesis, the femoral fixation was not standardized and was mostly performed using old devices that did not confer the stability that modern fixation/suspension implants provide. In this manner, they noted that the force required to pull out both grafts was similar, and that patellar tendon grafts were not more resistant than flexor tendons, when the latter were used in four bands. This was the first meta-analysis to demonstrate that the flexor tendon was superior. In both of these papers, the authors recommended that ACL reconstruction using flexor tendons from the thigh should be the gold standard technique because of the greater stability and lower morbidity of the procedure<sup>(1-4,10,13,15,18)</sup>. In another meta-analysis recognized for its high quality of elaboration, Biau *et al*<sup>(3)</sup> pointed out another possible bias that would lead to false superiority of the patellar tendon technique: some authors had standardized on similar rehabilitation for the two techniques, although it is known that flexor tendons require slower rehabilitation. This could have led to overestimation of the stability results with patellar tendons<sup>(3,15)</sup>. Their study demonstrated that there was no evidence that patellar tendons were more stable, and showed that the flexor tendon technique presented significantly lower morbidity.

It is now well established in the literature that the anterior and rotational stability of the knee is dependent on the graft fixation method used for ACL reconstruction<sup>(1,15,16,18)</sup>. The fixation depends on the

quantity of graft filling the tunnels, the application point and the distribution of the traction forces. The types of fixation used can be classified as: a) fixation by compression (interference screw); b) fixation by expansion (*rigidfix*); and c) fixation by suspension (*endobutton* and *cross-pin*)<sup>(16)</sup>. Flexor tendon grafts undergo histological and biochemical changes, into a structure resembling that of the ACL<sup>(10)</sup>. The mechanical behavior is directly proportional to the contact area between the implant and the cortical bone<sup>(16)</sup>. Recently, a new technique for ACL reconstruction was proposed, consisting of flexor tendons arranged in a double band with separate tunnels, with the aim of greater anterior and rotational stability in relation to grafts in four bands in a single tunnel<sup>(27-30)</sup>. However, further studies are necessary, since contradictory results have been obtained<sup>(28)</sup>.

The use of sutures for fixation on the tibial pillar (second-generation fixation) in association with femoral fixation using *endobutton* has been shown to be an excellent combination for fixation of flexor tendon grafts, since this allows tensioning independently of the four tendon bands, thereby increasing the stability and resulting in better tension than with fixation by friction<sup>(10,15,18)</sup>.

In relation to ethnicity, reconstruction using the flexor tendons presents a notable advantage over patellar tendons among Asians and Muslims, given their cultural habits of kneeling and sitting cross-legged. These movements, when performed postoperatively after reconstruction using patellar tendons, trigger significant anterior pain in the knee<sup>(3,4,8,9)</sup>. In our study, ethnicity did not form part of the methodology.

The mean age of the study group corresponded to the ages encountered in many other reports in the literature, thus showing that this injury mainly affects patients from halfway through the second to halfway through the third decade of life<sup>(2-4,9,14,15)</sup>.

The Lysholm index is one of the subjective evaluation methods most used for following up patients who undergo knee surgery, and it has become established in the literature because of its sensitivity, reproducibility and reliability<sup>(17,22)</sup>. The results obtained, both generally and segmented according to sex, show the high efficacy and effectiveness of the surgery proposed, for both sexes<sup>(1)</sup>. Similar data are found in different types of publication, whether meta-analyses or clinical trials, thus proving the efficiency of the technique in subjective evaluations<sup>(1,2,7-9,11,30)</sup>.

There was no significant difference in the Lysholm indices through stratification by sex in our study. Studies have shown that the satisfactoriness of the results from ACL repair using flexor tendons is not influenced by the patients' sex<sup>(1)</sup>. Comparing reconstructions using patellar tendons and flexor tendons, the latter has been shown to be preferable for treating female patients, since the lower levels of scarring and morbidity produce less pain and a faster return to pre-injury activity levels<sup>(26)</sup>.

Our study also evaluated patients according to their body weight, using BMI calculations, which are a practical and reproducible marker<sup>(19)</sup>. Comparing the patients with normal BMI with those presenting overweight and grades I and II obesity, the proportions of the results that were good and excellent in the two groups were similar. This shows that this technique can be indicated even for patients in whom the demands on the knee joint relating to bearing the body weight are greater. Eriksson *et al*<sup>(8)</sup> presented similar results from a sample of composition similar to ours, which included patients with BMI > 25 and in the same age range.

Lastly, the variable of the presence of leg fractures as the initial traumatic event generating the ACL injury did not change the functional and subjective results from ligament reconstruction among the patients in our sample. Thus, the flexor tendon technique is feasible, resolves the problem and produces good and excellent results even in patients with fractures in bone segments adjacent to the knee joint.

Through these results, and as demonstrated and ratified in other, previously established studies, flexor tendon grafts in four bands with cortical fixation and suspension of the femur and second-generation fixation of the tibia has become the present state of the art. It forms an excellent method for ACL reconstruction since the results presented are equal to or better than those from patellar tendons, with lower morbidity<sup>(1-4,8,10,13,15,16,18)</sup>.

## CONCLUSIONS

The technique of ACL reconstruction using autografts from the flexor tendons of the thigh demonstrated good and excellent results in 91.4% of the sample.

Male patients seemed to present a greater tendency towards good and excellent results.

No statistically significant difference was observed when the results were analyzed in relation to BMI or to associations with an initial traumatic episode of leg fracture.

## REFERÊNCIAS

1. Prodromos CC, Han YS, Keller BL, Bolyard RJ. Stability results of hamstring anterior cruciate ligament reconstruction at 2- to 8-year follow-up. *Arthroscopy*. 2005;21(2):138-46.
2. Harilainen A, Linko E, Sandelin J. Randomized prospective study of ACL reconstruction with interference screw fixation in patellar tendon autografts versus femoral metal plate suspension and tibial post fixation in hamstring tendon autografts: 5-year clinical and radiological follow-up results. *Knee Surg Sports Traumatol Arthrosc*. 2006;14(6):517-28.
3. Biau DJ, Tournoux C, Katsahian S, Schranz PJ, Nizard RS. Bone-patellar tendon-bone autografts versus hamstring autografts for reconstruction of anterior cruciate ligament: meta-analysis. *BMJ*. 2006;332(7548):995-1001.
4. Poolman RW, Abouali JA, Conter HJ, Bhandari M. Overlapping systematic reviews of anterior cruciate ligament reconstruction comparing hamstring autograft with bone-patellar tendon-bone autograft: why are they different? *J Bone Joint Surg Am*. 2007;89(7):1542-52.
5. Shelbourne KD, Gray T. Anterior cruciate ligament reconstruction with autogenous patellar tendon graft followed by accelerated rehabilitation. A two-to nine-year followup. *Am J Sports Med*. 1997;25(6):786-95.
6. Aglietti P, Buzzi R, Zaccherotti G, De Biase P. Patellar tendon versus doubled semitendinosus and gracilis tendons for anterior cruciate ligament reconstruction. *Am J Sports Med*. 1994;22(2):211-7.
7. Williams RJ 3rd, Hyman J, Petrigliano F, Rozental T, Wickiewicz TL. Anterior cruciate ligament reconstruction with a four-strand hamstring tendon autograft. *J Bone Joint Surg Am*. 2004;86(2):225-32.
8. Eriksson K, Anderberg P, Hamberg P, Löfgren AC, Bredenberg M, Westman I, et al. A comparison of quadruple semitendinosus and patellar tendon grafts in reconstruction of the anterior cruciate ligament. *J Bone Joint Surg Br*. 2001;83(3):348-54.
9. Ibrahim SA, Al-Kussary IM, Al-Misfer AR, Al-Mutairi HQ, Ghafar SA, El Noor TA. Clinical evaluation of arthroscopically assisted anterior cruciate ligament reconstruction: patellar tendon versus gracilis and semitendinosus autograft. *Arthroscopy*. 2005;21(4):412-7.
10. Larson RV, Kweon Q. Anterior cruciate ligament reconstruction with hamstring tendon autografts and endobutton femoral fixation. *Techn Knee Surg*. 2005;4(1):36-46.
11. Williams RJ 3rd, Hyman J, Petrigliano F, Rozental T, Wickiewicz TL. Anterior cruciate ligament reconstruction with a four-strand hamstring tendon autograft. Surgical technique. *J Bone Joint Surg Am*. 2005;87 Suppl 1(Pt 1):51-66.
12. Yunes M, Richmond JC, Engels EA, Pinczewski LA. Patellar versus hamstring tendons in anterior cruciate ligament reconstruction: A meta-analysis. *Arthroscopy*. 2001;17(3):248-57.
13. Elmlinger BS, Nyland JA, Tillett ED. Knee flexor function 2 years after anterior cruciate ligament reconstruction with semitendinosus-gracilis autografts. *Arthroscopy*. 2006;22(6):650-5.
14. Goldblatt JP, Fitzsimmons SE, Balk E, Richmond JC. Reconstruction of the anterior cruciate ligament: meta-analysis of patellar tendon versus hamstring tendon autograft. *Arthroscopy*. 2005;21(7):791-803.
15. Prodromos CC, Joyce BT, Shi K, Keller BL. A meta-analysis of stability after anterior cruciate ligament reconstruction as a function of hamstring versus patellar tendon graft and fixation type. *Arthroscopy*. 2005;21(10):1202.
16. Milano G, Mulas PD, Ziranu F, Piras S, Manunta A, Fabbriani C. Comparison between different femoral fixation devices for ACL reconstruction with doubled hamstring tendon graft: a biomechanical analysis. *Arthroscopy*. 2006;22(6):660-8.
17. Lysholm J, Gillquist J. Evaluation of knee ligament surgery results with special emphasis on use of a scoring scale. *Am J Sports Med*. 1982;10(3):150-4.
18. Prodromos CC, Joyce BT. Hamstring ACL Reconstruction: technique, results, meta-analysis and posterior graft harvest technique. *Techn Knee Surg*. 2006;5(2):87-95.
19. Pi-Sunyer FX, Becker DM, Bouchard C, Carleton RA, Colditz GA, Dietz WH, et al. Clinical guidelines on the identification, evaluation and treatment of overweight and obesity in adults – The evidence report. Bethesda: National Institute of Health Publication; 1998. (Publicação no. 98-4083).
20. Pflörringer W, Kremer C. [Subsequent treatment of surgically managed, fresh, anterior cruciate ligament ruptures—a randomized, prospective study]. *Sportverletz Sportschaden*. 2005;19(3):134-9.
21. Raynor MC, Pietrobon R, Guller U, Higgins LD. Cryotherapy after ACL reconstruction: a meta-analysis. *J Knee Surg*. 2005;18(2):123-9.
22. Anderson AF. Rating scales. In: Fu FH, Harner CD, Vince KG, editors. *Knee surgery*. Baltimore: Williams & Wilkins; 1994. p. 275-96.
23. Burks RT, Crim J, Fink BP, Boylan DN, Greis PE. The effects of semitendinosus and gracilis harvest in anterior cruciate ligament reconstruction. *Arthroscopy*. 2005;21(10):1177-85.
24. Eriksson K, Hamberg P, Jansson E, Larsson H, Shalabi A, Wredmark T. Semitendinosus muscle in anterior cruciate ligament surgery: Morphology and function. *Arthroscopy*. 2001;17(8):808-17.
25. Harilainen A, Linko E, Sandelin J. Randomized prospective study of ACL reconstruction with interference screw fixation in patellar tendon autografts versus femoral metal plate suspension and tibial post fixation in hamstring tendon autografts: 5-year clinical and radiological follow-up results. *Knee Surg Sports Traumatol Arthrosc*. 2006;14(6):517-28.
26. Feller JA, Siebold R, Webster KE. ACL Reconstruction in females: patellar tendon versus hamstring tendon autograft. *J Bone Joint Surg Br*. 2005;87(Suppl 3):305.
27. Muneta T, Sekiya I, Yagishita K, Ogiuchi T, Yamamoto H, Shinomiya K. Two-bundle reconstruction of the anterior cruciate ligament using semitendinosus tendon with endobuttons: operative technique and preliminary results. *Arthroscopy*. 1999;15(6):618-24.
28. Freedman KB, D'Amato MJ, Nedeff DD, Kaz A, Bach BR Jr. Arthroscopic anterior cruciate ligament reconstruction: a metaanalysis comparing patellar tendon and hamstring tendon autografts. *Am J Sports Med*. 2003;31(1):2-11.
29. Siebold R, Dehler C, Ellert T. Prospective randomized comparison of double-bundle versus single-bundle anterior cruciate ligament reconstruction. *Arthroscopy*. 2008;24(2):137-45.
30. Asagumo H, Kimura M, Kobayashi Y, Taki M, Takagishi K. Anatomic reconstruction of the anterior cruciate ligament using double-bundle hamstring tendons: surgical techniques, clinical outcomes, and complications. *Arthroscopy*. 2007;23(6):602-9.