



## Original Article

# Functional results from reconstruction of the anterior cruciate ligament using the central third of the patellar ligament and flexor tendons<sup>☆</sup>



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## ABSTRACT

**Objectives:** To evaluate knee function in patients undergoing reconstruction of the anterior cruciate ligament (ACL) using the central third of the patellar ligament or the medial flexor tendons of the knee, i.e. quadruple ligaments from the semitendinosus and gracilis (ST-G), by means of the Knee Society Score (KSS) and the Lysholm scale.

**Methods:** This was a randomized prospective longitudinal study on 40 patients who underwent arthroscopic ACL reconstruction between September 2013 and August 2014. They comprised 37 males and three females, with ages ranging from 16 to 52 years. The patients were numbered randomly from 1 to 40: the even numbers underwent surgical correction using the ST-G tendons and the odd numbers, using the patellar tendon. Functional evaluations were made using the KSS and Lysholm scale, applied in the evening before the surgical procedure and six months after the operation.

**Results:** From the statistical analysis, it could be seen that the patients' functional capacity was significantly greater after the operation than before the operation. There was strong evidence that the two forms of therapy had similar results ( $p > 0.05$ ), in all the comparisons.

**Conclusions:** The results from the ACL reconstructions were similar with regard to functional recovery of the knee and improvement of quality of life, independent of the type of graft. It was not possible to identify the best method of surgical treatment. The surgeon's clinical and technical experience and the patient are the factors that determine the choice of graft type for use in ACL surgery.

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## Resultados funcionais da reconstrução do ligamento cruzado anterior com o terço central do ligamento patelar e os tendões flexores

### R E S U M O

#### Palavras-chave:

Ligamento cruzado anterior

Joelho

Tratamento

**Objetivos:** Avaliar a função dos joelhos em pacientes submetidos à reconstrução do ligamento cruzado anterior (LCA), com o terço central do ligamento da patela (TP) ou os tendões flexores mediais do joelho (semitendíneo e grácil quádruplos: ST-G) ipsilaterais, por meio do Knee Society Score (KSS) e da escala de Lysholm.

**Métodos:** Estudo longitudinal, prospectivo e randomizado, com 40 pacientes submetidos à reconstrução do LCA por via artroscópica, de setembro de 2013 a agosto de 2014, dos quais 37 eram do sexo masculino e três do feminino, com de 16 a 52 anos, enumerados de forma aleatória de 1 a 40. Os números pares foram submetidos à correção cirúrgica com os tendões do ST-G e os números ímpares com o TP. Foram aplicados para a avaliação funcional o KSS e a escala de Lysholm na noite anterior ao procedimento cirúrgico e com seis meses de pós-operatório.

**Resultados:** Em análise estatística foi possível observar que no pós-operatório a capacidade funcional dos pacientes foi significativamente maior do que no pré-operatório. Há fortes evidências de que ambas as terapêuticas sejam similares em seus resultados ( $p = >0,05$ ), em todas as comparações.

**Conclusões:** Os resultados da reconstrução do LCA, independentemente do tipo de enxerto, são similares na recuperação funcional do joelho e na melhoria da qualidade de vida. Não foi possível identificar melhor método de tratamento cirúrgico. A experiência clínica, a técnica do cirurgião e o paciente são quem ditam a escolha do tipo de enxerto que deverá ser usado para a cirurgia do LCA.

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## Introduction

Anterior cruciate ligament (ACL) injuries are the commonest ligament injuries of the knee. Considering that tears of this ligament mainly affect young individuals who practice sports, the treatment instituted needs to provide these patients with the conditions for them to return to their sport.<sup>1</sup>

With the aim of achieving this objective, many techniques have been developed for reconstructing the ACL, especially over the last 30 years, using autografts, allografts or synthetic grafts, including through advances in arthroscopic techniques.<sup>2</sup> Today, the two options most commonly used for ACL reconstruction using autografts involve use of the medial hamstring muscles, quadruple semitendinosus and gracilis (ST-G) and the central third of the patellar ligament (PT).<sup>3</sup>

Recently, many systems have been developed for evaluating the pre and postoperative results from patients who undergo surgical procedures on the knee.<sup>4</sup> Use of these scales serves as an evaluation parameter and thus makes it possible measurements to be standardized and made uniform and reproducible, in relation to treatment proposals.

The Knee Society Score (KSS) combines subjective and objective information; separates the knee score (pain, stability, range of motion, etc.) from patients' functional scores (ability to walk and go up and down stairs); and assesses the clinical condition with regard to pain intensity, range of motion, anteroposterior and mediolateral stability, contractures during flexion, deformities and misalignment.<sup>5</sup>

The Lysholm scale is one of the questionnaires most used for evaluating knee symptoms. It is composed of eight questions, with closed alternatives for the responses, and the final result is expressed both in words and in numbers: "excellent", from 95 to 100 points; "good", from 84 to 94 points; "fair", from 65 to 83 points; and "poor", when the values are less than or equal to 64 points.<sup>6</sup>

The present study had the aim of evaluating patients who underwent surgical treatment for arthroscopic reconstruction of the ACL using an autograft from the ST-G or PT. To achieve this objective, the KSS and Lysholm scales needed to be used, applied during the immediate preoperative period and after six months of follow-up, in order to ascertain whether one technique might be superior to the other (ST-G versus PT).

## Materials and methods

Between September 2013 and August 2014, a randomized prospective longitudinal study was conducted among patients for whom surgical treatment for ACL injuries had been indicated, because of complaints of instability and positive physical and complementary examinations. These operations were performed using an ipsilateral autograft either from the central third of the patellar ligament (PT) or from the medial flexor tendons of the knee, i.e. the semitendinosus and gracilis (ST-G).

The inclusion criteria considered were that the patients needed to have been properly registered at the knee surgery

outpatient clinic, with a confirmed diagnosis of ACL injury alone, with an authorization for hospitalization requested, and with an operation performed only by the principal investigator. The criteria considered for exclusions comprised situations of complex knee injuries (involving multiple ligaments, osteoarthritis and meniscal injuries), revision surgery, inflammatory pathological conditions, obesity (body mass index > 30), withdrawal of the patient, operations performed by other surgeons and refusal to sign the free and informed consent statement. Patients were only counted within the methodology and within the statistical analysis on the results if they met all of the inclusion criteria.

Forty authorizations for hospitalization were gathered from the appropriate sector of our institution. From these documents, forty patients who had been scheduled for arthroscopic ACL reconstruction were numbered randomly (from 1 to 40). Those with even numbers underwent surgical correction using the ipsilateral ST-G, fixed with an Endobutton® CL in the femur and a titanium interference screw in the tibia. Those with odd numbers received the ipsilateral PT by means of a single incision, fixed with two titanium interference screws, in the femur and in the tibia. All the surgical procedures were performed under spinal anesthesia, with a tourniquet at the root of the thigh of the limb to be operated, with a pressure of 350 mmHg. The grafts were harvested according to the patient's group. Arthroscopy was performed and the femoral tunnel was constructed starting from the anteromedial portal at the center of the scar of the native ACL. The tibial tunnel was created using a specific guide, with the exit at the center of the native ACL. The postoperative rehabilitation protocol was the same for all the patients. It was implemented at the institution's own physiotherapy service, where the physiotherapists were unaware of the research project that was in progress.

The group of patients with even numbers was composed of one female patient (5%) and 19 male patients (95%). The ages of these patients ranged from 16 to 52 years, with a mean of 32 (standard deviation  $\pm$  8 years), and nine patients (45%) were in the age group from 30 to 39 years. The left and right sides were affected at the same rate (50%).

The group of patients with odd numbers was composed of two female patients (10%) and 18 male patients (90%). The ages of these patients ranged from 18 to 48 years, with a mean of  $32 \pm 9$ , and nine patients were in the age group from 30 to 39 years. The right side was operated in 11 patients (55%) and the left in nine (45%).

The Knee Society Score and the Lysholm scale, which have been validated for the Portuguese language, were used to evaluate the functional results. The first of these combines subjective and objective information and the second of these presents eight questions with closed alternatives as the responses, and they were applied in the evening before the surgical procedure and six months after the operation, with an active search for patients if they did not return for the outpatient consultation. All the patients were operated by the senior author, who has experience of treating knee injuries. This author did not participate in the process of applying the questionnaire before and after the operation.

All the patients evaluated in this study signed a free and informed consent statement. The study was submitted to the institution's research ethics committee and was

approved under the ethics assessment certificate (CAAE) number 18321113.5.0000.0007.

The data were tabulated in the Microsoft Excel® software and the results were presented in tables, graphs and measurements (mean, standard deviation (SD) and coefficient of variation). Descriptive and inferential analyses were performed on the results. All the comparisons relating to the KSS and Lysholm were performed by means of the Mann-Whitney test. The significant level was taken to be 5% in all of these comparisons. All of the variables were analyzed using the Minitab statistical software, version 14.1.

## Results

To ensure the precision of the comparisons, the homogeneity of the two samples was ascertained. Taking the significance level to be 5%, it was observed from Levene's test that homogeneity of the sample was assured ( $p > 0.05$ ). In other words, the ages, genders and sides affected were statistically equal (Table 1).

Among the ACL reconstruction results, both from patients who received ST-G autografts (Table 2) and from those with PT grafts (Table 3), it could be seen through the Mann-Whitney

**Table 1 – Homogeneity test on the patient sample studied, who underwent ACL reconstruction using ST-G and PT autografts.**

Characteristics	Standard deviation		p value <sup>a</sup>
	ST-G	PT	
Age	8.565	9.136	0.782
Gender <sup>b</sup>	0.224	0.308	0.560
Side affected <sup>b</sup>	0.513	0.510	0.664

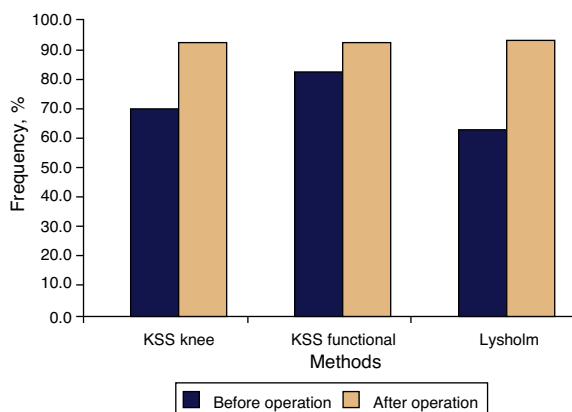
ST-G, medial knee flexors; PT, central third of patellar tendon.  
<sup>a</sup> Levene's test.  
<sup>b</sup> Gender and side affected were coded numerically in order to apply the test.

**Table 2 – Comparison of the functional capacity of the patients of the ST-G group according to the KSS and Lysholm scales.**

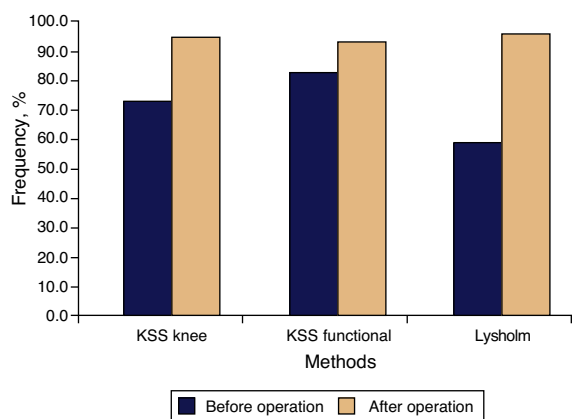
Methods	Median		p value
	Before operation	After operation	
KSS knee	67.5	90.0	0.0001
KSS functional	80.0	90.0	0.0001
Lysholm	60.5	90.5	0.0001

**Table 3 – Comparison of the functional capacity of the patients of the PT group according to the KSS and Lysholm scales.**

Methods	Median		p value
	Before operation	After operation	
KSS knee	70.0	91.5	0.0001
KSS functional	80.0	90.0	0.0001
Lysholm	56.5	92.5	0.0001



**Fig. 1 – Comparison of the methods for evaluating the functional capacity before and after the operation, among the patients who received ST-G autografts.**



**Fig. 2 – Comparison of the methods for evaluating the functional capacity before and after the operation, among the patients who received PT autografts.**

test that there was strong evidence that after the operation, the patients' functional capacity was significantly greater than before the operation, taking the significance level to be 5% ( $p < 0.05$ ).

Figs. 1 and 2 show geometrically that both on the KSS and on the Lysholm scale there was a significant improvement after the operation in both groups (ST-G and PT, respectively).

In comparing functional capacity from before to after the operation among patients who underwent both therapeutic methods (Table 4), it could be seen through the Mann-Whitney test (which uses the median as the parameter) that there was strong evidence that the two therapeutic methods had similar results in all comparisons ( $p > 0.05$ ).

## Discussion

The ACL presents poor potential for spontaneous healing when it is completely torn. Around two-thirds of the patients with this injury evolve to a high degree of knee instability, which worsens with the return to physical activities, results in recurrent subluxation and evolves to future functional incapacity, meniscal lesions and early appearance of osteoarthritis (OA).<sup>7-10</sup> Among the patients with ACL tears alone or in combination with meniscal lesions or injuries to collateral ligaments, 60–90% evolve to radiographic alterations indicative of osteoarthritis within 10–15 years, with the onset of symptoms occurring 10–20 years earlier than among patients with primary OA.<sup>11,12</sup>

Conservative treatment of ACL injuries may function reasonably well under certain circumstances, especially in patients who present minimal exposure to high-risk activities and good adaptation to ligament insufficiency, or when an advanced process of degenerative arthritis in the knee involved can already be seen.<sup>13</sup>

Over the last two decades, the commonest question regarding ACL surgery has been “which is the best graft to choose?” The PT used to be considered to be the gold standard for ACL reconstruction. The reasons for this include the strength of the graft, the relative ease of harvesting it and the bone-to-bone healing with secure fixation. Recently, use of ST-G autografts has gained in popularity among surgeons' choices.<sup>14</sup> The current trend toward increased use of the ST-G comes from the care taken to avoid the potential negative effect on the extensor mechanism that may ensue from the PT, along with the morbidity in the PT donor area, which may include anterior knee pain and the risk of fracturing the patella.<sup>15</sup> Nonetheless, despite the increasing popularity

**Table 4 – Comparison of functional capacity from before to after the operation among the patients who underwent both therapeutic methods (medial knee flexors and central third of the patellar ligament).**

Time	Therapy	KSS knee		KSS functional		Lysholm	
		Median	SD	Median	SD	Median	SD
Before operation	ST-G	67.5	11.1	80.0	14.4	60.5	12.9
	PT	70.0	9.6	80.0	11.3	56.5	14.1
	<i>p</i> value <sup>a</sup>	0.250		0.449		0.797	
After operation	ST-G	90.0	7.1	90.0	10.8	90.5	10.0
	PT	91.0	3.1	90.0	5.1	92.5	6.0
	<i>p</i> value <sup>a</sup>	0.091		0.273		0.685	

SD, standard deviation; ST-G, medial knee flexors; PT, central third of patellar tendon.

<sup>a</sup> Mann-Whitney test – significance level of 5% (0.05).

of ST-G grafts, they also have potential limitations, including slower graft incorporation into the tunnel than seen with the PT, potential widening of the tunnels and residual laxity and functional weakness of the flexor musculature on the side from which the graft is harvested.<sup>16,17</sup> In Brazil, as long ago as 1999, Camanho and Andrade<sup>18</sup> stated that although the middle third of the patellar ligament together with bone fragments from the patella and tibia was for a long time considered to be the ideal graft, use of autografts from the tendons of the medial flexor muscles was becoming widely disseminated because of their efficiency, fixation method and low aggression of the donor area, and comparisons with the use of middle third of the patellar tendon were starting to be made in the literature.

However, in making comparisons between patients with torn ACLs that were treated surgically and patients followed up conservatively, Meunier et al.<sup>19</sup> concluded that there were significantly more meniscal lesions in patients who were managed conservatively, and that one-third of these cases evolved to surgical treatment because of joint instability.

Among authors who have considered that surgical treatment is the first option, ACL reconstruction has been advocated with the objective of restoring the normal kinematics of the joint. In this manner, the instability and the potential associated damage to the menisci and chondral surfaces are eliminated. Almost universally, indications for ACL reconstruction are made in relation to patients who present high risks through their lifestyle, with demands through heavy work, sports or recreational activities that might reproduce episodes of subluxation of the knee.<sup>13</sup>

Many studies have already been conducted to compare the autografts used in treatments for ACL injuries, and these have showed their benefits and harm for patients after the operation.<sup>20-28</sup>

Corry et al.<sup>20</sup> made a comparison of the postoperative results among patients who underwent ACL reconstruction arthroscopically, using ST-G or PT autografts. They came to the conclusion that there was no statistically significant difference between the two groups, in terms of ligament stability, range of motion (ROM) and general symptoms, two years after the procedure.

In a study by Keays et al.,<sup>21</sup> similar results could be seen, with restoration of clinical stability and muscle strength between the surgical groups and controls, although there was a deficit of 6% in quadriceps strength after using PT grafts.

Eriksson et al.<sup>22</sup> also concluded that there was no clinical difference over the medium term, between groups that underwent ACL reconstruction with the ST-G or PT. Likewise, Ahlen and Liden<sup>23</sup> did not find any statistically significant differences in relation to muscle strength, joint instability or ROM among their patients, who were evaluated two years after the surgical procedure.

However, Samuelsson et al.<sup>24</sup> and Muellner et al.<sup>25</sup> observed that the autograft harvesting site initially affected muscle strength and that use of the PT produced more pain in the anterior region of the knee than did the ST-G. However, both of these authors stated that these symptoms disappeared over the course of time.

According to Keays et al.,<sup>26</sup> the incidence of osteoarthritis after ACL reconstruction is worrisome, with reports that up

to 50% of these patients develop it moderately or severely, six years after the procedure. These authors noted that this event occurred because of the presence of chondral lesions, choice of the PT as the autograft, presence of a weak quadriceps, low resistance ratios of the quadriceps and hamstrings and meniscectomy performed at the time of the surgery. Based on these results, they recommended that in clinically unstable knees, ACL reconstruction should not be unnecessarily postponed, so as to avoid future meniscal and chondral lesions.

Pinczewski et al.<sup>27</sup> found prospectively that use of the PT increased the incidence of osteoarthritic radiographic alterations in these patients' knees, and also that the observed fixed deformities of flexion could presage the appearance of degenerative lesions.

Nonetheless, the ideal time for ACL reconstruction probably depends on the individual factors of each patient, such as the condition of the knee and the patient's motivation to undergo surgery and rehabilitation.<sup>23</sup>

In 2012, Mascarenhas et al.<sup>3</sup> concluded that both types of autograft allowed around 70% of young athletes to return to some degree of vigorous or very vigorous physical activity (4-7 times a week). ACL reconstruction using flexor tendons leads to better preservation of extension, better patient scores and less evidence of osteoarthritis. Although we found numerically superior scores in relation to the ST-G, these differences were not statistically significant.

In a level I systematic review, Reinhardt et al.<sup>28</sup> concluded that the risk of failure of ACL reconstruction is significantly greater with the ST-G than with the PT. The ST-G was superior in relation to residual laxity. Anterior knee pain was more present in reconstructions using the PT. In relation to activity level and functional evaluations, neither technique was superior to the other.

In 2013, Kim et al.<sup>29</sup> did not identify any significant differences in the clinical results and stability after ACL reconstruction, in relation to the type of graft or fixation device chosen. Thus, surgeons should select the "ideal" ACL reconstruction method according to the patient's conditions and the surgeon's experience.<sup>29</sup> These findings were corroborated by Abbas et al.,<sup>30</sup> who highlighted the concerns regarding anterior knee pain and patellofemoral symptoms through use of the PT.

In 2014, Papalia et al.<sup>31</sup> showed that there were no difference between groups reconstructed using the ST-G or PT, in any of the clinical scores or functional tests.

In the present study, it could be seen that there was a statistically significant improvement after the operation, among the patients in both groups studied (Knee Society Score and Lysholm). In comparing the present study with those investigated in the literature, similarities in the results could be observed when the Lysholm scale was used.<sup>20-23</sup> However, no relevant data were found in relation to using the KSS scale in the literature investigated, which thus makes it impossible to compare the results obtained in the present study.

Among the limitations of the present study, the short postoperative evaluation period (six months) can be cited. This study did not have the objective of following up the evolution of secondary lesions that might have occurred (meniscal and associated ligament lesions), or the development of osteoarthritis. The muscle deficit was not evaluated:

quadriceps for the PT or flexor for the ST-G. Evaluation of the criteria for the return to sport was not an objective of this study.

## Conclusion

The results from the ACL reconstructions using autografts from the central third of the patellar tendon or medial knee flexors were similar with regard to functional recovery of the knee and improvement of quality of life. Thus, because of the proximity of the statistical results from this study, it was not possible to precisely identify the surgical treatment that would provide greatest benefit for patients, with least aggression. Therefore, we believe that clinical experience, the surgeon's technique and respect for patients' individuality make the difference at the time of choosing the type of autograft for use in surgical treatment to reconstruct the ACL.

## Conflicts of interest

The authors declare no conflicts of interest.

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