



## Original article

# Correlation between the result from arthroscopic reconstruction of the anterior cruciate ligament of the knee and the return to sports activity<sup>☆</sup>

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### ABSTRACT

**Objective:** To evaluate the return to pre-injury sports activity in a group of patients who underwent anterior cruciate ligament (ACL) reconstruction, in relation to age, sex, body mass index (BMI) and associations with upper-limb fractures.

**Methods:** A group of 265 patients who underwent ACL reconstruction using an ipsilateral graft from the thigh flexor tendons, between July 2000 and November 2007, was analyzed.

**Results:** A total of 176 patients was evaluated after a mean period of  $34.95 \pm 18.8$  months (median: 31 months) (interquartile range: 20–48 months). The minimum evaluation period was 12 months and the maximum was 87 months. The number of patients who returned to their sports activity prior to tearing the ACL was 121/176 (68.8%). Patients under 30 years of age more frequently returned to sports activity and this was considered significant:  $p = 0.016$ ; odds ratio, OR = 0.44 (95% confidence interval, CI: 0.22–0.86). Returning to previous sports activity more frequently was not considered significant for male sex ( $p = 0.273$ ), individuals with BMI < 25 ( $p = 0.280$ ) or patients with an ACL injury unrelated to an initial traumatic episode with upper-limb fracturing ( $p = 0.353$ ).

**Conclusions:** The rate of return to the sports activity prior to ACL injury was 68.8%. It was found that patients under the age of 30 years had a significantly greater rate of return to sports activity after the surgery. In relation to sex, BMI and association with an initial traumatic episode of upper-limb fracturing, there was no statistical difference in the return to sports activity.

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## Correlação entre o resultado da reconstrução artroscópica do ligamento cruzado anterior do joelho e o retorno à atividade esportiva

### R E S U M O

#### Palavras-chave:

Ligamento cruzado anterior

Joelho

Atividade motora

**Objetivo:** Avaliar o retorno à atividade esportiva pré-lesional num grupo de pacientes submetidos à reconstrução do ligamento cruzado anterior (LCA) com relação à idade, ao sexo, ao IMC e à associação com fratura no MI.

**Métodos:** Foi analisado um grupo de 265 pacientes submetidos à reconstrução do LCA com enxerto ipsilateral dos tendões flexores da coxa entre julho de 2000 e novembro de 2007.

**Resultados:** Foram avaliados 176 pacientes com uma média de  $34,95 \pm 18,8$  meses (mediana 31) (IIQ: 20-48 meses). A avaliação mínima foi aos 12 meses e a máxima aos 87 meses. O número de pacientes que retornaram à atividade esportiva prévia à ruptura do LCA foi de 121/176 (68,8%). O retorno mais frequente à atividade esportiva entre os pacientes até 30 anos foi considerado significativo ( $p=0,016$ ) [OR=0,44 (95% IC 0,22-0,86)]. Não foi considerado significativo o retorno mais frequente à atividade esportiva prévia para o sexo masculino ( $p=0,273$ ) para os indivíduos com IMC < 25 ( $p=0,280$ ) e para pacientes com a lesão do LCA não relacionada a um episódio inicial traumático com fratura no MI ( $p=0,353$ ).

**Conclusões:** O índice de retorno à atividade esportiva prévia à lesão do LCA foi de 68,8%. Foi verificado de forma significativa que pacientes com idade até 30 anos têm um maior índice de retorno à atividade esportiva após a cirurgia. Com relação ao sexo, IMC e à associação com um episódio inicial traumático de fratura no MI não houve diferença estatística para o retorno à atividade esportiva.

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## Introduction

Anterior cruciate ligament (ACL) deficiencies are a common pathological condition that may lead to changes in quality of life.<sup>1</sup> Joint instability is the main cause of functional incapacity of the knee, and it obliges individuals who are in an active phase of life to modify their professional activities and their participation in sports activities.<sup>2</sup>

Conservative treatment for ACL injuries may produce good results, but has limited capacity for returning patients to the sports activities that they practiced previously.<sup>3</sup>

Surgical treatment of knee instability with a specific approach for ACL deficiencies has presented major evolution over recent decades.<sup>4</sup> Unrestricted return to the sports level prior to injury is considered to be an indicator of success in reconstructing the ACL.<sup>5</sup> However, there are large differences between objective measurements of knee stability after ACL operations and patients' subjective assessments of their satisfaction after the surgical procedure, influenced by social, cultural, financial and even psychological factors.<sup>2,5</sup>

The objective of this study was to evaluate the rate of return to pre-injury sports activities among a group of patients who underwent ACL reconstruction with autografting of flexor tendons from the thigh. Data relating to age, sex, body mass index (BMI) and associated initial traumatic episodes of lower-limb fracturing were analyzed.

## Materials and methods

This study was retrospective and cross-sectional; 265 patients who underwent knee arthroscopy for the purposes of

isometric ACL reconstruction using an ipsilateral graft from the flexor tendons of the thigh were analyzed. The surgical procedures took place between July 6, 2000, and November 19, 2007. The indication for ACL reconstruction surgery was a complaint of knee instability in a patient with an interest in sports practice or difficulties relating to professional performance. Patients in whom an Endobutton had been used for femoral fixation and a cortical screw and metal washer for tibial fixation of the graft were included in this study.

Patients who underwent other surgical techniques or the following additional procedures were excluded from the study: tibial valgus osteotomy, posterolateral reconstruction, simultaneous reconstruction of the posterior cruciate ligament (PCL), osteochondroma resection and meniscal suturing. In addition, patients with the following characteristics were excluded: ACL revision surgery, follow-up of less than 12 months and presentation of lower-limb abnormalities such as muscle loss due to burn sequelae, metaphyseal deformity, subtalar arthrodesis, post-traumatic neuropraxia of the sciatic nerve and history of septic arthritis.

The anesthesia applied was subarachnoid block using heavy bupivacaine (15–20 mg/kg) with addition of morphine at a dose of 0.1–0.2 mg/kg. The procedure was always performed by the same surgeon, with the patient positioned in dorsal decubitus and a pneumatic tourniquet applied to the lower limb. No aspiration drain was used. A compressive dressing was applied and the lower limb was kept fully extended.<sup>6</sup> Cryotherapy was used as an adjuvant method in all cases.<sup>7</sup> The postoperative protocol was home-based for the great majority of the patients. Postoperative return visits were made 15 days and one, two, four, six and twelve months after the procedure. The patients were released for sports movements six months

after the operation and for contact sports eight months after the operation.<sup>8</sup>

The variables studied were sex, age, BMI, association with an initial episode of lower-limb fracture and return to the pre-injury sports activity.

The data were analyzed by means of the Statistical Package for the Social Sciences (SPSS) software, version 12.0 (SPSS Inc., 1989-2003). Calculations on the means, standard deviations, medians, frequencies and percentages were used for the statistical analyses. Student's *t* test and one-way ANOVA were used to compare the means of symmetrical variables. The nonparametric Mann-Whitney test was used to analyze asymmetrical variables and the  $\chi^2$  (chi-square) test was used to compare frequencies. Differences with  $p \leq 0.05$  for a 95% confidence interval were considered to be significant.

## Results

In this study, 265 patients were evaluated; of these, 76 were excluded, thus leaving a total of 189. There was a sample loss of 13 patients (6.87%): two because of death and 11 because of follow-up loss. In total, 176 patients were evaluated, at a mean of  $34.95 \pm 18.8$  months after the operation (median of 31 months) (interquartile range, IQR: 20-48 months). The earliest evaluation was 12 months after the operation and the longest interval was 87 months. The mean age was  $32.6 \pm 10.1$  years. The youngest patient was 13 years of age and the oldest was aged 54 years. In this sample, 131 patients (74.4%) were male and 45 (25.6%) were female. The mean age among the males was  $32.4 \pm 9.6$  years and among the females,  $33.1 \pm 11.4$  years. The number of right knees operated was 81 (46%) and left knees, 95 (54%).

The number of operated patients who returned to their sports activity prior to tearing the ACL was 121/176 (68.8%). The mean age among the patients who returned to sports activity was  $31.4 \pm 9.6$  years, while the mean age among the patients who did not return was  $35.2 \pm 10.6$  years. A statistically significant difference was found between the two groups. The patients who returned to sports activity had a lower mean age ( $p = 0.020$ ). By performing the statistical analysis with a cutoff point at the age of 30 years, it was seen that 78.2% of the patients under 30 years of age returned to sports activity, while 61.2% of those over the age of 30 years did so. This difference was considered to be significant ( $p = 0.016$ ) [OR = 0.44 (95% CI: 0.22-0.86)]. On analyzing the return to sports activity in relation to sex, it was seen that 93 of these patients (71%) were male and 28 (62.2%) were female. The greater frequency of returning to the previous physical activity among male patients was not significant ( $p = 0.273$ ). In relation to the 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 obesity grade 1 and three (1.7%) were classified as presenting obesity grade 2. There were no patients with morbid obesity in this sample. It was seen that 59 patients (72.8%) with BMI that was considered to be normal (BMI < 25) returned to sports activity. Through grouping the patients with BMI > 25 (overweight, obesity grade 1 and obesity grade 2), it was seen that 62 (65.3%) returned to sports activity. There was no

statistically significant difference between these two groups ( $p = 0.280$ ).

In the present sample, 17 patients (9.7%) presented ACL injuries relating to an initial traumatic episode with lower-limb fracturing, in the tibial condyle, femur or tibia. The mean age of these patients was  $36.8 \pm 10$  years (median 39 years). The mean age of the remainder of the sample was  $32.1 \pm 10$  years (median 32 years). No statistical difference was seen between these two groups ( $p = 0.070$ ).

It was seen that 10 patients (58.8%) with an ACL injury relating to an initial traumatic episode with lower-limb fracturing returned to work. On analyzing the remainder of the sample, it was seen that 111 patients (69.8%) returned to sports activity. There was no significant difference in relation to returning to sports activity between these two groups ( $p = 0.353$ ).

## Discussion

The objective of surgical treatment for knees with ACL deficiencies is to stabilize the condition so as to prevent injuries after the patient has returned to sports at the same level as practiced previously.<sup>9</sup> This is difficult to evaluate, given that the following need to be taken into consideration: sports activity level, type of sport practiced, expectations from the result, capacity to engage in the rehabilitation process, stress generated by the treatment and duration of the rehabilitation period. Deeham et al.<sup>10</sup> demonstrated that sedentary patients may present better results than individuals engaged in competitive activities.

In indicating surgical treatment of any type, orthopedists need to discuss this with their patients and ascertain their expectations regarding the results. It is no different for ACL reconstruction indications.

Based on the sports classification of the American Medical Association, a division can be made between contact sports (boxing, soccer, basketball, handball and American football) and non-contact sports (tennis, swimming, golf and athletic throwing events).<sup>11</sup> Our study did not evaluate the different types of sports practiced, but only took into consideration previous sports activity among the sample.

The return to sports activity is multifactorial and involves surgical issues, rehabilitation and demographic, psychological and social factors. Age seems to be important, since elderly patients are less likely to return to sports. It is also important to differentiate between returning to the previous sport and returning to the previous sports level, since the rates for these are very different. Even a return to the previous competitive status does not signify that the previous sports competency will be maintained.<sup>12</sup>

Dunn et al.<sup>13</sup> reported that a previous high sports level was the main predictor for returning to sport over a two-year follow-up, whereas female sex, high BMI and smoking during the first six months were associated with lower rates of return to sport. Other authors have also indicated that gender is an important variable, but that the differences disappear over the long term.<sup>12</sup>

The long-term success rates for intra-articular ACL reconstruction alone seen in the literature range from 75% to 95%,

for good and excellent results, taking into consideration the variables of stability, symptom relief and return to sports.<sup>14</sup>

The rate of return to any degree of sports practice after ACL reconstruction ranged from 26% to 97%<sup>15</sup>; to the pre-injury activity level, 63%; and to competitive practice, 44%.<sup>16</sup>

Some authors have assessed the return to sports activity according to the surgical technique used. Guimarães et al. compared ACL reconstructions using a graft from the patellar tendon with a graft from the quadriceps tendon. They found that 25% of the patients returned to sports at a lower level than originally after surgery using patellar tendon, and 8.6% using the quadriceps tendon.<sup>17</sup> Among the patients who underwent the patellar tendon grafting technique, 12.5% reported that they abandoned their sport because of complaints of instability or pain and 12.5% because of fear of injury recurrence.<sup>17</sup> Aglietti et al.<sup>18</sup> found that 50% of their patients returned to physical activity at a level similar to the pre-injury level when the flexor tendons of the thigh were used, and 66% when the patellar tendon technique was used. We used the ACL reconstruction technique using the flexor tendons of the thigh in all our sample. Comparison between the surgical techniques and their results relating to the sports levels recovered gained new perspectives in a recent study.<sup>19</sup> It was found that 74% in the patellar tendon group returned to demanding sports and 70% in the flexor tendon group. However, only 57% of the patellar tendon group and 44% of the flexor tendon group returned to the pre-injury activity level. The flexor tendon technique presented a significant improvement in preservation of extension, better subjective indices and less radiographic evidence of lateral osteoarthritis.<sup>19</sup>

Smith et al.<sup>2</sup> followed up a group of 62 athletes for 12 months and found that 81% returned to their sports activity. However, 21% presented impairment of performance. Nakayama et al.<sup>20</sup> also evaluated athletes and found that 92% returned to sports activity. The greater return to sport in these two studies was mainly because they were conducted among professional athletes. These subjects had better means of rehabilitation available and greater psychological stimulation for returning to their physical activity. In the present study, we evaluated patients in a random sample, including some athletes. We found a rate of return to sports activity of 68.8%, i.e. similar to what can be seen in the literature.

Pain as a limitation to sports activity was more common when the patellar tendon graft technique was used. According to O'Brien et al.,<sup>21</sup> the rate of pain in the anterior region of the knee after ACL reconstruction using this technique was 30%. Lower values were found by Corry et al.<sup>22</sup> and Nakayama et al.<sup>20</sup> when the flexor tendon technique was used for ACL reconstruction (7% and 6%, respectively). In our study, we evaluated the patients by means of the Lysholm score, in which one of the items relates to pain. However, we did not consider pain separately as an objective of this study.

As also reported by Smith et al.,<sup>2</sup> the return to physical activity at pre-injury levels among men was 71% in the present study. There was no statistically significant difference in relation to the rate among women (62.2%).

In the studies by Nakayama et al.<sup>20</sup> and Smith et al.,<sup>2</sup> the mean age of the patients was less than 30 years, and the results relating to returning to physical activity at professional level were excellent. Smith et al.<sup>2</sup> also observed that age greater than 35 years, chronic ACL injury and preexisting pathological conditions in the knee were factors limiting good postoperative results. Arden et al.<sup>23</sup> showed that older patients had lower rates of return to sports. In our study, age up to 30 years was shown to be a protection factor with regard to returning to sports after ACL reconstruction surgery using grafts from the flexor tendons of the thigh.

Shelbourne et al.<sup>15</sup> demonstrated that adolescents of mean age 15 years who were soccer and basketball players presented the following rates of return to their previous sports status: 87% (basketball), 93% (females, soccer) and 80% (males, soccer). Out of this group, 20% maintained their competitive level during the university period. There was no statistical difference between the sexes or between the sports played with regard to injury recurrence or contralateral injury. Early return (after three to four months) did not show a greater rate of subsequent ACL injuries in relation to later return (after more than six months).

We did not find any studies that evaluated the relationship between return to sports activity after ACL reconstruction and an initial traumatic episode of lower-limb fracturing.

There was a significant correlation between weight and femoral quadriceps strength.<sup>24</sup> Schmitt et al.<sup>24</sup> evaluated the influence of quadriceps strength and the return to sports activity. Individuals who presented strength that had diminished by more than 15% in relation to the contralateral limb were affected negatively in relation to function and performance. The other group' (strength > 85%) presented results that were similar to those of the control group (patients without ACL injuries). The patients with lower quadriceps strength were heavier ( $p < 0.025$ ) than the control group and the group with strength loss of up to 15%.

The ideal time for returning to sports practice is still a challenge. It has been postulated that this time could be reached when the affected limb has attained 90% of the capacity of the contralateral limb for performing the same activities.<sup>25</sup> In a recent systematic review, Barber-Wesrin and Noyes<sup>9</sup> sought to identify factors that might define the time to return to sports after ACL reconstruction. Only 35 studies that used measurable variables were identified. Of these, only two were based on associations of four to five objective criteria for assessing whether it would be appropriate to release the patient for physical activity. Therefore, although muscle strength, neuromotor control and stability are important criteria with regard to release for sports practice, papers that are more homogeneous are still required in the literature in order supply these data.<sup>9,16</sup> The association between absence of joint effusion and episodes of instability (IKDC index > 93) presented a positive predictive value for estimating the return to previous sports status.<sup>26</sup>

We consider that the heterogeneity of the study group regarding the sports practiced was a limitation of our study, even though this is the reality of Brazilian orthopedic practice. Smith et al.<sup>2</sup> stated that athletic patients' psychological profile and motivation toward returning to sports may contribute directly to the results encountered.

## Conclusion

The rate of return to the sports activity prior to ACL injury among the patients who underwent reconstruction using an autograft from the flexor tendons of the thigh was 68.8%.

It was observed that patients below the age of 30 years had a significantly higher rate of return to sports activity after the surgery.

There were no statistical differences for the return to sports activity, in relation to sex, BMI or association with an initial traumatic episode of lower-limb fracturing.

## Conflicts of interest

The authors declare no conflicts of interest.

## REFERENCES

- Schueda MA, Santos OJR, Farias ABV. Parafuso de interferência absorvível versus metálico na ligamentoplastia do cruzado anterior. *Rev Joelho*. 2002;2(2):1.
- Smith FW, Rosenlund EA, Aune AK, MacLean JA, Hillis SW. Subjective functional assessments and the return to competitive sport after anterior cruciate ligament reconstruction. *Br J Sports Med*. 2004;38(3):279-84.
- Noyes FR, Matthews DS, Mooar PA, Grood ES. The symptomatic anterior cruciate-deficient knee. Part II: The results of rehabilitation, activity modification, and counseling on functional disability. *J Bone Joint Surg Am*. 1983;65(2):163-74.
- Colombet P, Allard M, Bousquet V, de Lavigne C, Flurin PH, Lachaud C. Anterior cruciate ligament reconstruction using four-strand semitendinosus and gracilis tendon grafts and metal interference screw fixation. *Arthroscopy*. 2002;18(3):232-7.
- Lee DY, Karim SA, Chang HC. Return to sports after anterior cruciate ligament reconstruction – a review of patients with minimum 5-year follow-up. *Ann Acad Med Singapore*. 2008;37(4):273-8.
- Pförringer W, Kremer C. Subsequent treatment of surgically managed, fresh, anterior cruciate ligament ruptures—a randomized, prospective study. *Sportverletz Sportschaden*. 2005;19(3):134-9.
- Raynor MC, Pietrobon R, Guller U, Higgins LD. Cryotherapy after ACL reconstruction: a meta-analysis. *J Knee Surg*. 2005;18(2):123-9.
- Mello Júnior WA, Marchetto A, Prado AMA. Reabilitação funcional do joelho nas reconstruções ligamentares – Programa domiciliar. In: Pardini AG, Souza JMG, Mello Júnior WA, editors. *Clínica ortopédica. Lesões ligamentares do joelho*. Rio de Janeiro: Medsi; 2000. p. 695-9.
- Barber-Westin SD, Noyes FR. Factors used to determine return to unrestricted sports activities after anterior cruciate ligament reconstruction. *Arthroscopy*. 2011;27(12):1697-705.
- Deehan DJ, Salmon LJ, Webb VJ, Davies A, Pinczewski LA. Endoscopic reconstruction of the anterior cruciate ligament with an ipsilateral patellar tendon autograft. A prospective longitudinal five-year study. *J Bone Joint Surg Br*. 2000;82(7):984-91.
- American Medical Association. Committee on the Medical Aspects of Sports. In: *Medical evaluation of the athlete: a guide*. Chicago: American Medical Association; 1976.
- Feller J, Webster KE. Return to sport following anterior cruciate ligament reconstruction. *Int Orthop*. 2013;37(2):285-90.
- Dunn WR, Spindler KP, Moon Consortium. Predictors of activity level 2 years after anterior cruciate ligament reconstruction (ACLR): a Multicenter Orthopaedic Outcomes Network (Moon) ACLR cohort study. *Am J Sports Med*. 2010;38(10):2040-50.
- Wetzler MJ, Bartolozzi AR, Gillespie MJ. Revision anterior cruciate ligament reconstruction. *Oper Tech Orthop*. 1996;6:181-9.
- Shelbourne KD, Sullivan AN, Bohard K, Gray T, Urch SE. Return to basketball and soccer after anterior cruciate ligament reconstruction in competitive school-aged athletes. *Sports Health*. 2009;1(3):236-41.
- Ardern CL, Webster KE, Taylor NF, Feller JA. Return to sport following anterior cruciate ligament reconstruction surgery: a systematic review and meta-analysis of the state of play. *Br J Sports Med*. 2011;45(7):596-606.
- Guimarães MV. Reconstrução artroscópica do ligamento cruzado anterior: estudo comparativo entre os enxertos autólogos de ligamento patelar e de tendão do quadríceps. *Rev Bras Ortop*. 2004;39(1):30-41.
- 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.
- Mascarenhas R, Tranovich MJ, Kropf EJ, Fu FH, Harner CD. Bone-patellar tendon-bone autograft versus hamstring autograft anterior cruciate ligament reconstruction in the young athlete: a retrospective matched analysis with 2-10 year follow-up. *Knee Surg Sports Traumatol Arthrosc*. 2012;20(8):1520-7.
- Nakayama Y, Shirai Y, Narita T, Mori A, Kobayashi K. Knee functions and a return to sports activity in competitive athletes following anterior cruciate ligament reconstruction. *J Nippon Med Sch*. 2000;67(3):172-6.
- O'Brien SJ, Warren RF, Pavlov H, Panariello R, Wickiewicz TL. Reconstruction of the chronically insufficient anterior cruciate ligament with the central third of the patellar ligament. *J Bone Joint Surg Am*. 1991;73(2):278-86.
- Corry IS, Webb JM, Clingeleffer AJ, Pinczewski LA. Arthroscopic reconstruction of the anterior cruciate ligament. A comparison of patellar tendon autograft and four-strand hamstring tendon autograft. *Am J Sports Med*. 1999;27(4):444-54.
- Ardern CL, Taylor NF, Feller JA, Webster KE. Return-to-sport outcomes at 2 to 7 years after anterior cruciate ligament reconstruction surgery. *Am J Sports Med*. 2012;40(1):41-8.
- Schmitt LC, Paterno MV, Hewett TE. The impact of quadriceps femoris strength asymmetry on functional performance at return to sport following anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther*. 2012;42(9):750-9.
- Return to sport: when should an athlete return to sport after an ACL surgery? *J Orthop Sports Phys Ther*. 2011;41(6):388.
- Lentz TA, Zeppieri Jr G, Tillman SM, Indelicato PA, Moser MW, George SZ, Chmielewski TL. Return to preinjury sports participation following anterior cruciate ligament reconstruction: contributions of demographic, knee impairment, and self-report measures. *J Orthop Sports Phys Ther*. 2012;42(11):893-901.