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Original Research

Isokinetic flexion strength recovery after ACL reconstruction: a comparison between all inside graft-link technique and full tibial tunnel technique

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Abstract:

Introduction: Recently, a new minimally invasive single bundle technique for anatomic ACL reconstruction has been described, called the "All-Inside graft-link technique". One of the advantages of this procedure is the reduced morbidity at the donor site as the graft choice is the quadrupled semitendinosus, thus sparing the gracilis tendon. The aim of this study was to evaluate isokinetic flexion strength recovery in patients who underwent a gracilis sparing technique compared to those with a full-tibial tunnel technique using a doubled gracilis and semitendinosus tendons (DGST) graft.

Methods: Patients were divided in two groups: Group A (22 patients) who underwent ACL reconstruction performed with an All-Inside graft-link technique; Group B (22 patients) who underwent ACL reconstruction with an Out-In technique and DGST graft. At a mean follow-up of 13 months, quadriceps and hamstring isokinetic peak torque deficits were recorded.

Results: In group A, the mean side to side peak torque flexion difference between the operated and non-operated limbs was -3% and the mean torque at 30° was -7.5% at high angular velocity (180°/sec); the mean peak flexion torque was 7.2% and the mean torque at 30° was 3.1% at low angular velocity (60°/sec).

In group B, the mean side to side peak flexion torque was -3.5% and the mean torque at 30° was -7.6% at high angular velocity (180°/sec); the mean peak flexion torque

was -7.2% and the mean torque at 30° was -11% at low angular velocity (60°/sec).

A statistically significant difference was found between the two groups at lower angular velocity both for the mean peak flexion torque and the mean torque at 30° (p=0.009), with better results in the study group.

Discussion/Conclusion: Gracilis sparing technique is a minimally invasive technique for ACL reconstruction and yielded a significantly better flexion strength recovery at lower angular velocity compared to a full tibial tunnel technique with DGST for ACL reconstruction.

INTRODUCTION

Injuries to the anterior cruciate ligament (ACL) occur in the general population, but are particularly common in athletes involved in cutting sports [1-3] To restore knee stability and decrease the risk of subsequent injury (e.g., meniscus tears), ACL reconstruction (ACLR) is often performed with excellent results in most cases [4-6]. Although ACLR is one of the most common orthopedic procedures, the choice of graft remains controversial [6]. BPT grafts have been associated with higher donor site morbidity and loss of extension strength during isokinetic testing [7-9]. Conversely, hamstring grafts, have been associated with more residual laxity and worse recovery in flexion strength, especially at deeper knee flexion angle [10]. Recently, a new minimally invasive single bundle technique for anatomic ACL reconstruction has been described, called the "All-Inside graft-link technique" [11].

One of the advantages of this procedure is the reduced morbidity at the donor site as the graft choice is the quadrupled semitendinosus, thus sparing the gracilis tendon. Although literature [12] has already investigated the effect of hamstring harvesting on flexion strength recovery, very few reports exist regarding the effect of additional gracilis harvesting on hamstring strength recovery. The aim of this study was to evaluate isokinetic flexion strength recovery in patients who underwent ACL reconstruction using the gracilis sparing All-Inside graft-link technique compared to those with a full-tibial tunnel technique using a doubled gracilis and semitendinosus

tendons (DGST) graft. The hypothesis of the present study is that the All-Inside graft-link technique guarantees a better flexion strength recovery.

MATHERIAL AND METHODS

Following institutional review board approval, a retrospective analysis was performed for patients admitted from January 2015 to May 2015 for chronic ACL tears. Forty-four patients with an ACL tear operated on for an ACL reconstruction gave their consent to be enrolled in this study. Inclusion criteria included chronic ACL tear (mean 8 months, range 5 to 13 months), complete ACL tear revealed by a positive Lachman and pivot-shift test (1 to 3); minimum 1 year follow-up. Exclusion criteria included associated ligament injuries to the PCL, MCL and LCL ias detected by MRI and/or clinical examination (varus or valgus stress, recurvatum and posterior drawer test positive), presence of a Segond's fracture, age > 40 years, a body mass index (BMI) > 30, and previous knee surgery. Patients with meniscal tears or cartilage damage was included in the study. Patients were divided in two groups: Group A (study group) included 22 patients (7 female, 15 male; mean age 32.5 ± 6.7) who underwent ACL reconstruction performed with an All-Inside graft-link technique [7]; Group B (control group) included 22 patients (5 female,17 male; mean age 31.7 ± 7.1) who underwent ACL reconstruction with an Out-In technique and DGST graft, fixed with an adjustable loop length device on femur (TightRope-RT Arthrex, Naples, FL) and an absorbable interference screw (Deltascrew, Arthrex, Naples, FL) on tibia. Research was conducted with approval of a formal ethics review committee and with written consent from the patients. Moreover the present study was performed following the principles of the Declaration of Helsinki.

Surgical technique

In group A, the harvested semitendinosus was quadrupled, sewn in linkage with a TightRope-RT (Arthrex, Naples, FL) on both side of the graft, and two high strength sutures (No. 0 FiberWire; Arthrex, Naples, FL) were placed on the tibial and on the femoral side of the graft, obtaining a final length of the graft of no more than 75 mm. Standard anterolateral (AL) and anteromedial portals were used. With a standard guide set at 60°, tibial bone socket was created on anatomic ACL insertion point using a specific retrodrill (Flipcutter, Arthrex, Naples, FL). Then, femoral bone socket was created with an out-in technique using a standard guide set approximately 100 to 110° and the same retrodrill as on the tibial side. The diameter of the drilling was determined after measuring graft diameter. Using a shuttle graft–passing suture on both sides, the graft was passed through the AM portal and fixed first on the femoral then on the tibial side with the "flip-then-fill technique" [11].

In group B, a double incision ACL reconstruction using doubled semitendinosus and gracilis tendons (DGST) autograft was performed using standard AL and AM portals. A k-wire was introduced on the anatomic tibial ACL insertion point using a standard guide set at 60° and then a full tibial tunnel was created using a drill of a diameter corresponding to the diameter of the DGST graft. On the femoral side, a bone socket was drilled with an Out-In technique and a standard guide set approximately 100° to 110° using a retrodrill (FlipCutter, Arthrex, Naples, FL) of the same diameter of the graft. The graft was then passed and fixed with TightRope-RT (Arthrex, Naples, FL) on the femoral side and with an interference screw on the tibial side. The diameter of the screw was always 1 mm more than the drilled tibial tunnel.

Postoperative rehabilitation

Each patient was placed in a full extension brace for 2 weeks. From the second day following surgery isometric exercises for muscular strength were begun and progressive weight bearing as tolerated was encouraged. After 2 weeks the brace was removed in turn to start active ROM in order to regain full joint motion. In all cases, crutches and brace were definitively removed within the first 6 weeks. Isotonic and isokinetic exercises which were more demanding against resistance were allowed. At the third month after surgery, patients progressed towards progressive functional activities (running). Patients were allowed to return to sport specific training at 4–6 months after surgery. Patients were monitored during rehabilitation protocol at different steps (1-2-4 week and at 3-6-12months postoperatively).

Isokinetic flexion strength evaluation

At a mean follow-up of 13 months (range 12 to 14 months) quadriceps and hamstring isokinetic peak torque deficits were recorded using the Biodex System 4 PRO (Biodex Medical Systems, New York). (Img.1) The warm-up consisted of hamstring/quadriceps stretching and cycling. Before starting the test, patients were seated with their knee flexed at 90° and body, pelvis and knee were stabilized with straps to prevent unwanted movement. Then, five repetitions were performed at 60 and 180°/sec from 0° to 100° of flexion to familiarize the patient with the isokinetic training before measurement. After this warm-up, the test started with twenty repetitions performed unilaterally at 180°/sec. After a 1 minute rest period, the second trial consisted of five repetitions performed unilaterally at 60°/sec. The uninvolved knee was always tested first and the patient was asked to give his maximum effort. All data were registered by the machine software and the mean isokinetic peak torque of the involved limb was compared with that of the contralateral limb as the representative parameter for muscle strength. The mean peak flexion torque and the

mean torque at 30° of flexion of both trials were considered to assess the differences between the two groups.

Statistical analysis

A total sample size of 42 patients was considered adequate for the primary outcome of the study which was the overall comparison of the parameters evaluated in both groups, assuming an effect size of 0.25, a two-tailed α value of 0.05 (sensitivity of 95%) and a β value of 0.80 (study power, 80%). The calculation of sample size was performed using G*Power 3 software (Heinrich-Heine-University, Dusseldorf, Germany). Statistical analysis generated standard descriptive statistics: means, standard deviations, and proportions. The Mann-Whitney U test was applied to verify differences between the two groups. Statistical significance was set at $P< 0.05$. Statistical Package for social Sciences (SPSS) version 22 was used for calculations.

RESULTS

In group A (study group), the mean side to side peak torque flexion difference between the operated and non-operated limbs was -3% and the mean torque at 30° was -7.5% at high angular velocity (180°/sec); the mean peak flexion torque was 7.2% and the mean torque at 30° was 3.1% at low angular velocity (60°/sec).

In group B (control group), the mean side to side peak flexion torque was -3.5% and the mean torque at 30° was -7.6% at high angular velocity (180°/sec); the mean peak flexion torque was -7.2% and the mean torque at 30° was -11% at low angular velocity (60°/sec).

A statistically significant difference was found between the two groups at lower angular velocity both for the mean peak flexion torque and the mean torque at 30°

(p=0.009), with better results in the study group [Tab.1] Return to sports activity as evaluated using Tegner score pre and post operatively showed no significant differences between the two groups, results are summarized in [Tab.2]. No major complication, such as graft failure, infection, loss of range of motion or deep venous thrombosis was not reported in any groups.

DISCUSSION

The most important finding of this study is that the All-inside graft link gracilis-sparing technique yielded a significantly better flexion strength recovery at lower angular velocity compared to a full tibial tunnel technique with DGST for ACL reconstruction, so the primary hypothesis of the study is confirmed.

Although literature [12] has widely investigated the effect of hamstring harvesting on flexion strength recovery, especially in patients involved in sports needing deep knee flexion of over 70°, very few reports exist regarding the effect of additional gracilis harvesting on hamstring strength recovery. Tashiro et al. discovered that tendon harvest caused significant weakness of hamstring muscle strength at high knee flexion angles, but such weakness was minimized when preserving the gracilis tendon [13]. Yosmaoglu et al. [14] reported that additional harvest of the gracilis affects knee flexion isokinetic torque negatively at low angular velocity (60°/sec). Considering functional anatomy, the gracilis and semitendinosus muscles are parallel fibered muscles with long fiber lengths illustrating an eminent potential to shorten at long distances. On the other hand, the semimembranosus and biceps femoris muscle are unipennate muscles, characterized by short fiber lengths and a pennation angle that increased with increasing knee flexion angles [15]. These considerable differences seem to suggest that only the gracilis muscle may compensate for the function of the

harvested semitendinosus. Moreover, as suggested by Croce et al. [16] through analyzing surface electromyography of the knee-joint muscles during reciprocal isokinetic extension and flexion movements, gracilis muscle activity is higher at lower angular velocity. This is in agreement with our findings, which confirmed that the additional harvest of the gracilis has a detrimental role in isokinetic strength recovery of the hamstring. Gracilis sparing could be beneficial in extremely active patients involved in sport activity requiring deep knee flexion angles. Moreover, as some authors [17] have demonstrated weaker internal tibial rotation in patients who underwent ACL reconstruction with DGST, with a detrimental effect of additional gracilis harvesting especially in female patients [18], it has been speculated that this imbalance of rotational strength could have a role in dynamic stability and sports performance and that the weakness of the internal rotational torque may be a risk factor for re-injury after ACL reconstruction. This study has several limitations. First of all this is a retrospective non-randomized study with a short final follow-up, second patients, even if followed the same post-operative rehabilitation protocol, were not sent to the same rehabilitation center. However all patients were monitored at different steps (1-2-4 week and at 3-6-12months) during rehabilitation by the same researcher.

Finally isokinetic evaluation of hip abductor strength was not evaluated. However the study has also some strengths: good number of patients enrolled in the study, same senior experienced surgeon performed ACL reconstruction in both groups and

CONCLUSION

The All-inside graft link technique is a minimally invasive technique for ACL reconstruction using a quadrupled semitendinosus graft and two bone socket on femur

and tibia. The all inside graft link technique yielded a significantly better flexion strength recovery at lower angular velocity compared to a full tibial tunnel technique with DGST graft for ACL reconstruction.

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Declaration of interest

E Monaco and A Ferretti disclose work as consultants for Arthrex. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties. Peer reviewers on this manuscript have no relevant financial relationships to disclose.

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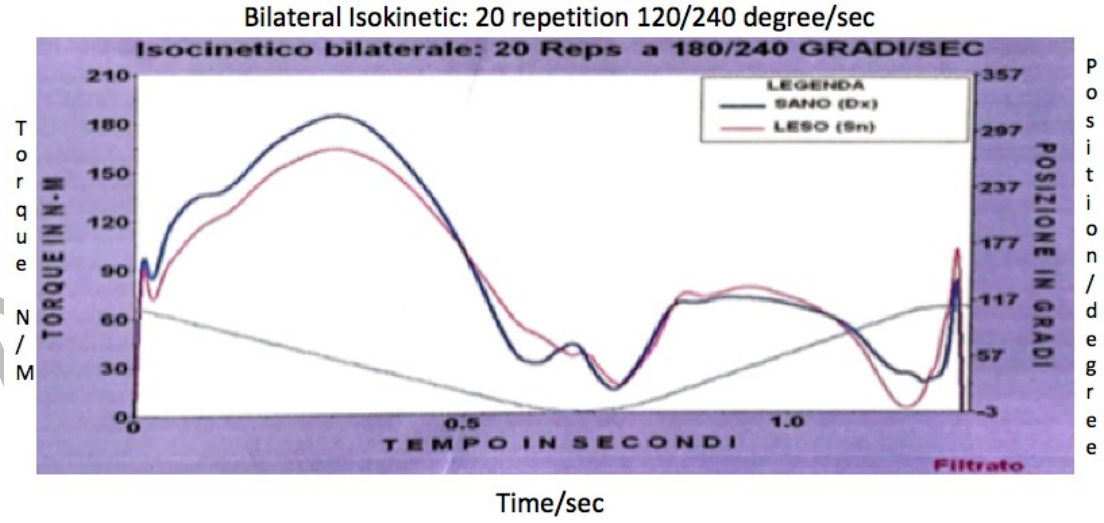
Legend to figures:

Table. 1 Isokinetic flexion strength. Comparison between the two groups at follow-up.

Table.2 Clinical Outcomes

Figure.1 Isokinetic flexion strength evaluation



	Angular velocity:180°/sec		Angular velocity:60°/sec	
	Peak flexion torque	**Torque at 30°**	**Peak flexion torque**	**Torque at 30°**
Group A*	**-3±8.4**	**-7.5±11.2**	**7.2±9.7**	**3.1±10.3**
Group B*	**-3.5±10**	**-7.6±15.4**	**-7.2±4.3**	**-11±11.2**
P value	**>0.05**	**>0.05**	**0.009**	**0.009**

*Values expressed as percentage (%) of strength of the involved versus uninvolved side;
± standard deviation.

Tab.1 Isokinetic flexion strength. Comparison between the two groups at follow-up.

Tegner score	Group A	Group B	p-value
Pre-op (Range)	**6 (6-9)**	**7(6-8)**	**n.s.**
Post-op (Range)	**6 (5-9)**	**6(6-8)**	**P=0.02**

Table.2 Clinical Outcomes