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ACL reconstruction with hamstrings: how different technique and fixation devices influence bone tunnel enlargement

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Abstract. – BACKGROUND: Bone tunnel enlargement after anterior cruciate ligament (ACL) reconstruction is well documented in the literature. The cause of this tunnel enlargement is unclear, but is thought to be multifactorial, with mechanical and biological factors playing a role.

AIM: The aim of this prospective study was to evaluate how the different techniques may affect the bone tunnel enlargement and clinical outcome.

PATIENTS AND METHODS: Forty-five consecutive patients undergoing ACL reconstruction with autologous doubled semitendinosus and gracilis tendons entered this study. They were randomly assigned to enter group A (In-Out technique, with cortical fixation and Interference screw) and group B (Out-In technique, metal cortical fixation on the femour and tibia). At a mean follow-up of 10 months, all the patients underwent CT scan exam to evaluate the post-operative diameters of both femoral and they underwent tibial tunnels clinical examination after 24 months.

RESULTS: The mean femoral tunnel diameter increased significantly from 9.05±0.3 mm to 10.01±2.3 mm in group A and from 9.04±0.8 mm to 9.3±1.12 mm in group B. The mean increase in femoral tunnel diameters observed in group A was significantly higher than that observed in group B ($p < 0.05$) The mean tibial tunnel diameter increased significantly from 9.03±0.04 mm to 10.68±2.5 mm in group A and from 9.04±0.03 mm to 10.±0.78 mm in group B. The mean increase in tibial tunnel diameters observed in group A was significantly higher than that observed in group B ($p < 0.05$). No clinical differences were found between two groups and no correlations between clinical and radiological results were found in any patients of both groups.

CONCLUSIONS: Results of the study suggest that different mechanical fixation devices could influence tunnel widening. The lower stiffness of the fixation devices is probably responsible of the tunnel widening through the fixation devices's micromotions in the femoral and tibial tunnels.

Key Words:

Bone tunnel enlargement, ACL reconstruction, TC evaluation, Mechanical factors, Stiffness.

Introduction

Bone tunnel enlargement after anterior cruciate ligament (ACL) reconstruction is well documented in the literature[1-3]. The cause of this tunnel enlargement is unclear, but is thought to be multifactorial, with mechanical and biological factors playing a role[4]. The potential factors contributing to this phenomenon include type of graft, motion of the graft within the tunnel, type of fixation and fixation devices, improper tunnel placement, aggressive rehabilitation and synovial fluid leakage within bone tunnel[5].

A secure fixation technique is needed to withstand the forces on the graft resulting from current rehabilitation protocols that allow for unrestricted range of motion (ROM), weightbearing, and early return to athletic activity after ACL reconstruction[6]. Current techniques include suspensory fixation[7], joint line fixation with interference screws[8], and transfemoral fixation with crosspins[9]. The femoral fixation of the semitendinous-gracilis (STG) tendons using an EndoButton (Smith and Nephew, Andover, MA, USA) appeared to be reliable as well as sufficiently resistant and rigid[10] but for some authors[11,12] this indirect fixation distant from the joint space could be the source of graft micromovements in the femoral tunnel responsible for enlarging this tunnel.

Despite no clinical correlation between tunnel enlargement and poor clinical result has been shown[13], it is clear that a wide bone tunnel filled with fibrous tissue can be difficult to treat in cases of revision surgery.

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A few studies[14] during the past decade have focused on ways on minimizing bone loss and tunnel enlargement after using hamstrings for ACL reconstruction. The hypothesis was that there would be less tunnel enlargement using stiffer fixation devices that could reduce mechanical factors.

The purpose of this study was prospectively to compare femoral and tibial tunnel enlargement and functional outcomes following arthroscopic ACL reconstruction with quadruple-hamstring autograft using two different surgical techniques.

Patients and Methods

We selected 45 patients (33 males and 12 females) affected by unilateral chronic ACL instability. The mean age of the patients was 32 years (range: 17-49) at the time of the surgery: all the surgical procedures were performed from May 2008 to April 2009 by the same surgeon (F.C.) with double gracilis and semitendinosus tendons (DGST).

All demographics data are showed in Table I. There are no statistic differences in both groups. They were randomly divided to enter group A or group B, where in the first group the reconstruction was performed with a standard single incision and an In-Out transtibial technique, while in the second group a two incisions technique was done and Out-In technique was performed for femoral tunnel. The groups are homogeneous.

Twenty-two patients entered the group A and twenty-three the group B.

There was no difference regarding the operative findings, follow-up time, age and gender between the groups.

Inclusion criteria for this study were the presence of a chronic and unilateral rupture of the ACL and an age lower than 40 years old. Exclusion criteria were: an age higher than 50 years old, patients with associated concomitant medial or lateral collateral ligament injury and patients with degenerative joint disease or chondral damage detected with pre-operative standard X-ray or Magnetic Resonance Imaging (MRI) exams.

Table I. Demografics data.

	Group IN-OUT	Group OUT-IN
Sex	16 men, 6 women	17 men, 6 women
Age (mean, SD)	31.63 ± 5.77	32.43 ± 8.39
Side	12 right, 10 left	11 right, 12 left

Surgical Technique

In the in-out group, the femoral tunnel was drilled through the tibial tunnel. The graft fixation was performed with the use of Bioabsorbable screws (BioRCI-HA) on the tibial side and with the Endobutton device (Smith and Nephew, Andover, MA, USA) on the femoral side.

In the out-in group, the Evolgate (Citieffe, Bologna, Italy) and the Swing-Bridge (Citieffe, Bologna, Italy) were used for the tibial and femoral fixation respectively.

In both groups bone tunnels were always performed with the same 9.0 mm drill on femoral and tibial sides in according to the graft size harvest.

Rehabilitative Protocol

The rehabilitative protocol was the same for both groups. A full extension locked brace was used for the first 2 weeks: isometric exercises for quadriceps strengthening, stretching of flexor apparatus and weight-bearing as tolerated with use of crutches were allowed by the second post-operative day. After the second week, the brace was removed and patients started exercises to regain a complete knee range of motion (ROM). After the first month, they were allowed to perform cycling and treadmill and to intensify muscular strengthening with closed kinetic chain exercises and with open kinetic chain sequentially.

Follow-up Evaluation

At a mean follow-up of 10 months (range: 9-12 months), all the patients underwent radiological evaluation and after 24 months clinical examination.

CT evaluation was done with a 16-slices MSCT scanner Philips MX 8000 and post-process multislab reconstructions on sagittal, coronal and axial planes were used for the analysis. The evaluation technique has just been described in a previous study[15].

All diameters were calculated in millimetres.

All the patients underwent a CT scan one day after the operation (Figures 1, 2) and at final follow-up (Figures 3, 4).

All measurements were completed by an independent musculoskeletal radiologist who was blinded to the treatment. The alignment was measured using the ruler application in the Centricity Enterprise Web V2.1 PACS viewing system (GE Healthcare, Chalfont St. Giles, Buckinghamshire, United Kingdom). To eliminate interobserver variability, a single musculoskeletal radiologist was used.

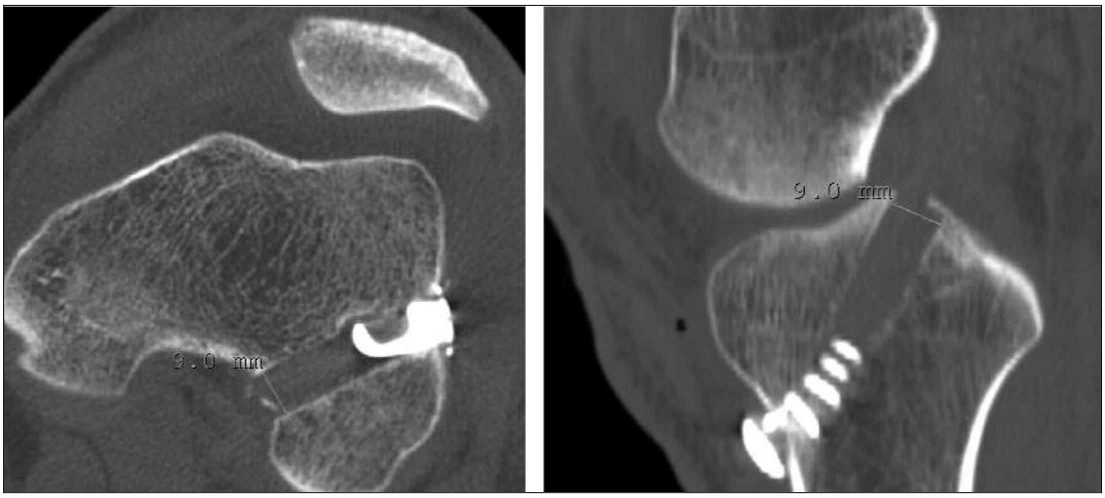

Figure 1. Post-operative CT in group Out-In. All the patients in group B underwent a CT scan one day after the surgery.

Figure 2. Post-operative CT in group In-Out. All the patients in group A underwent a CT scan one day after the operation.

Figure 3. Post-operative CT in group In-Out. All the patients in group A underwent a CT scan in the F.U.

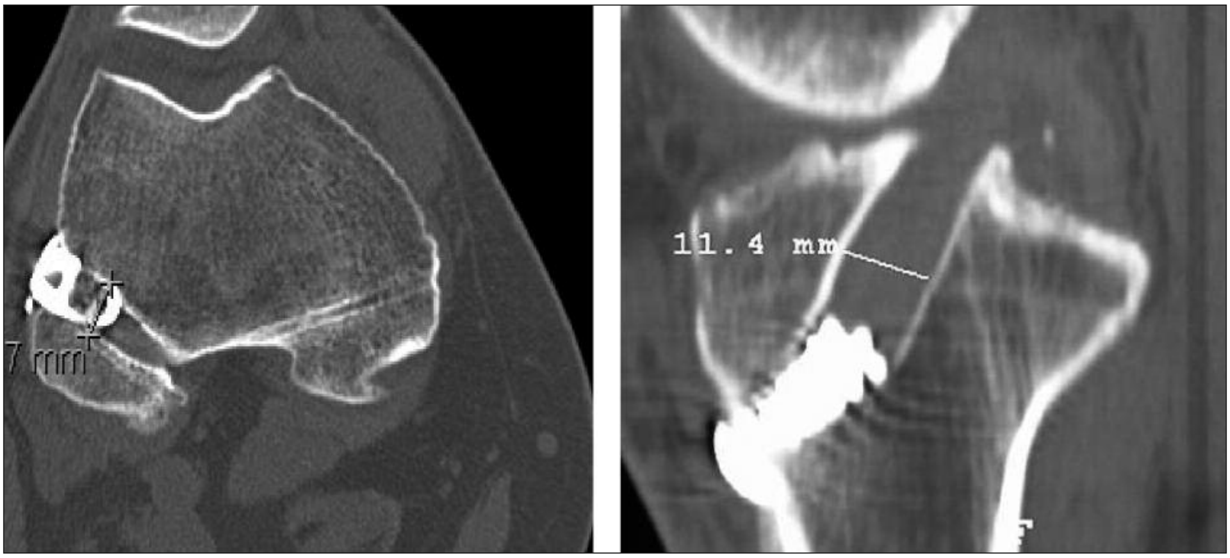

Figure 4. Post-operative CT in group Out-In. All the patients in group B underwent a CT scan in the F.U.

The CT measurements on the second postoperative day showed no significant difference to the intraoperative drill diameter in all patients which validates the drilling technique and the CT measurements.

All 45 patients were available for the follow-up at 10 months postoperatively.

Clinical follow-up included subjective evaluation with Tegner, Lysholm Scores, and physical exam performing and the objective knee laxity was measured by the KT-1000.

Statistical Analysis

Student's *t* test was used to compare the amount of tunnel enlargement between different groups. Pearson's correlation coefficient was used to characterize the relationship of tunnel enlargement to clinical parameters. All statistical analyses were performed with SPSS version 14.0 (SPSS, Inc., Chicago, IL, USA). Statistical significance was accepted at the 95% confidence level ($p < 0.05$).

Results

Radiological Evaluation

In group A (In-Out group) showed an average increase in diameter of the femoral tunnel from 9.05±0.3 mm to 10.01±2.3 mm with an increase of 11.4%. Patients of group B (Out-In group) showed a mean increase in the femoral tunnel from 9.04±0.8 mm to 9.30±1.12 mm (+2.8%). The difference among the two groups was statistically significant ($p < 0.05$).

In the tibial tunnel, the mean increase raised from 9.03±0.04 mm to 10.68±2.5 mm (+18.2%) in patients of group A (In-Out group), and from 9.04±0.03 mm to 10.±0.78 mm (10.4%) in patients of group B (Out-In group). Even in this case, the difference among the two groups was statistically significant ($p < 0.05$).

Clinical Evaluation

All data are showed in Table II. There were no statistically differences between groups.

All subjects regained full ROM, normal strength, normal functional performance and returned to their previous level of activity (mean 6 months, range 5-7).

However, no correlations between clinical and radiological results were found in any patients of both groups.

Discussion

The phenomenon of the bone tunnel widening has already been well documented in literature[16,17]. The extent of tunnel enlargement has been found

Table II. Clinical evaluation.

	Group A	Group B	*p*
Tegner	6.7 ± 2.1	6.6 ± 2.3	> 0.05
Lysholm	94.2 ± 6	95.1 ± 5	> 0.05
KT-1000 Side to side	1.8 ± 1,8	1.7 ± 1.7	> 0.05

to increase during the first three post-operative months[18] and then stays at a steady state or drops the following year. Therefore the time point for the CT investigation was 10 months. Unlike other studies, we have conducted measurements of the bone tunnels on CT scans rather than MRI scans[19], because there is evidence in the literature that MRI images are less accurate in the determination of tunnel widening[20].

The CT scans gave more reliable measurements than the standard radiographs. Conventional radiographs showed poor visibility, especially in the AP projection[21]. Furthermore we have just used an evaluation with the same technique previously described in literature[22].

The hypothesis of the study was confirmed. From the results obtained, there is a statistic difference between group A and B on the femoral side and the tunnel increased 11.4% and 2.8% respectively. On the tibial side the tunnel increased 18.2% (In-Out group) and 10.4% (Out-In group) and this difference is statistically significative.

Several authors compared different fixation devices to analyse tunnel enlargement.

Baumfeld et al[19] compared two different techniques with DSGT in which the reconstructions with the EndoButton (Smith & Nephew, Andover, MA) were compared with a double cross pin (The Rigid Fix Depuy-Mitek, Raynham, MA, USA). He radiologically studied these tunnels with X-Rays exams, discovering a greater enlargement in patients of group A (EndoButton) ($p < 0.05$). He observed significantly less tunnel widening with double cross-pin fixation compared to suspensory fixation (and no difference with either tibial fixation device), as these methods fix the graft close to the tunnel opening within the joint.

Kuscucu et al[23], in 2008 conducted a study of tunnels after reconstruction with hamstring and found with measurements on radiographs in AP and LL an increase in size in 12 months greater with Endobutton (43.71% of the femur and the tibia 51.11%) compared to double cross-pin (32.61% of the femur and the tibia 25.62%).

Simonian et al[24] analyzed 2 incision technique with an EndoButton femoral fixation with DGST. He found bigger average diameter in the tunnel for the endobutton group on femoral and tibial side. An explanation is that the eccentric position of the guidewire in the tibial tunnel may cause expansion of the tibial tunnel in the posterior direction.

This could explain tunnel expansion on the tibial side but not on the femoral side.

These studies compared two different technique of fixation device; we used graft suspensory fixation with a different rigidity.

We believe that the most plausible hypothesis is the involvement of several factors; those factors are mechanical and biological, which can also interact with each other. In another study[25] we observed in patients operated with the same surgical technique, but a different rehabilitative protocol, a greater enlargement of the tunnel in those who had carried out faster rehabilitation, in fact the movements and pump effect could affect the integration of the graft into the bone[26,27].

Regarding to the clinical results, we agree with the literature[28-30], because no differences were found in our study.

There is a criticism to the current research, for example the small sample size.

However, in this study we performed both techniques using the same graft, the same instruments, the same rehabilitation protocol but fixation devices with different mechanical and biological properties.

Results of this work seem to suggest that different mechanical fixation devices could influence tunnel widening.

The different stiffness of the fixation devices is probably responsible of the tunnel widening through the fixation devices' micromotions in the femoral and tibial tunnels.

Conclusions

The use of a stiffer fixation device seems to contribute to reduce the tunnel enlargement.

Conflict of Interest Statement

The authors declare that they no have conflict of interest and sources of financial support to the publication of this article.

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