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Long-Term Clinical and Radiographic Results of ACL Reconstruction: Retrospective Comparison Between Three Techniques (Hamstrings Autograft, Hamstrings Autograft With Extra-Articular Reconstruction, Bone Patellar Tendon Autograft)

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SUMMARY

Background. There is no consensus in the current literature on which surgical options render the best long-term results after ACL reconstruction in terms of clinical outcomes and development of radiographic osteoarthritis (AO).
The aim of this study is to investigate clinical and radiological results at long-term follow up after ACL reconstruction using hamstring tendons autograft (Group HT), hamstrings autograft with extra-articular reconstruction (Group HT-ER), and bone patellar tendon bone autograft (Group BPTB).
Methods. All patients were evaluated at final follow-up using Lysholm, International Knee Documentation Committee (IKDC), and Tegner scores. An arthrometric KT-1000 evaluation was also done. Comparative weight bearing radiographs were taken, including a skyline view for patellofemoral joint and analyzed according to Fairbank, Kellgren, and IKDC classification.
Sixty patients were selected for this retrospective study, 20 for each group. The minimum final follow-up was 10 years for each group. All patients were male and involved in sport activities (Tegner pre-injury >7).
Results. Subjective scores improved significantly in all groups, with no significative differences between groups (P<0,05).
The number of patients classified as C or D at the IKDC objective activity score was higher in Group HT (2/20, 10%), than in Group BTB (1/20, 5%) and Group HT-E (0/20, 0%).
In term of failure-rate, there were no difference between the three groups (P<0,05).
Radiologic evaluation shoved more arthritic changes in Group-BT in the patello-femoral joint (PMJ).
Conclusions. All the three techniques showed satisfactory results at long term follow up with no differences in term of subjective scores. Finally, there was a statistically significant higher incidence of arthritic changes in PFJ as evaluated with x-ray in the BPTP group respect to HT and HT + ER groups (p<0.05).

KEY WORDS

Anterior cruciate ligament; extra articular reconstruction; hamstring tendon; knee joint; osteoarthritis; pivot-shift.

BACKGROUND

Anterior cruciate ligament (ACL) injury is a common occurrence, especially among young athletes. Restoring knee stability is thought to benefit not only in the short term with knee stabilization and patient return to sport, but also in the long term due to the increased risk of subsequent chondral or meniscal damage in the unstable knee (1).

Graft selection for anterior cruciate ligament reconstruction has been an intense research topic and debate subject for several decades. Hamstring tendon (HT) and patellar tendon (PT) autograft are currently the most utilized grafts in both research and clinical practice (2).

The PT autograft has its advantages due to the bone blocks at both ends of the graft, which facilitate ingrowth of the graft. However, the quadruple HT autograft is both a stiffer and stronger graft choice, with easy-to-manage harvest site morbidity. Even though the quadruple HT autograft is stronger, concerns have been raised about the risk of increased knee laxity over time (3).

Previous studies have reported that there are no differences in terms of rupture frequency between the two autografts (4–6). However, recent register studies have contested these results and indicated a higher rupture frequency in patients undergoing surgery using HT autografts (3–5).

In the last few years studies with long term follow-up showed that the addiction of an extraarticular reconstruction (ER) to an HT graft reduces the failure rate in comparison with HT or PT autograft without ER (7–9). However, there is still concern about over constrain of ER on knee kinematics, that may possibly lead to degenerative osteoarthritis (OA). There are few studies with long-term follow-up comparing simultaneously the different grafts with combined ER (10,11).

Patients who have sustained an ACL injury run the risk of developing post-traumatic OA, with the first signs of radiographic joint space narrowing at the age of as young as forty years (12,13). The incidence of radiographic OA ten to twenty years after an ACL injury has been estimated at approximately 50%, with a higher incidence in patients with combined injuries compared with isolated ACL ruptures (3,14).

In terms of the clinical outcomes and developments of radiographic OA, there is no true consensus in the current literature on which surgical option provides the best long-term results after ACL reconstruction.

The primary objective of this retrospective and multicenter study was to compare the effect of ACL reconstruction with HT graft, a combined reconstruction with HT graft and an ER, and ACL reconstruction with PT, regarding knee stability and function at long-term follow-up (minimum ten years). The secondary objective was to determine whether an ACL-reconstructed knee, in the three different groups, has a greater incidence of degenerative changes.

The primary hypothesis was that there is no difference in knee laxity and in clinical outcomes in the ACL-reconstructed knee with three different techniques.

The secondary hypothesis of this study was that there is no difference in the incidence and severity of knee OA in the ACL-reconstructed knee in the three different groups.

METHODS

Patients selection

For this retrospective and multicentric study, three series of patients (group PT, group HT, group HT-ER) that had previously undergone ACL reconstruction were selected.

Group HT and HT + ER were treated in the same facility by the same senior author (A.F.), while the group PT was treated by a different senior author (A.R.) in a different institute.

Exclusion criteria for all groups were as follows: female sex, Tegner activity score pre-injury<7(all patients were involved in sport activities at time of injury), BMI >29, older than thirty-five years at the time of surgery, severe associated ligamentous injuries as documented by laxity tests that were positive other than the Lachman and pivot shift tests, cartilage damage (grade 3 or 4 according to Outerbridge classification), previous knee surgery, and time elapsed from injury to surgery longer than 2 years (13).

Group HT included cases where an anatomic intra-articular ACL reconstruction with quadrupled hamstring graft was performed using out-in technique.

Group HT-ER included patients where the same technique for intra-articular reconstruction was used in association with an extra-articular tenodesis (McIntosh as modified by Coker and Arnold).

Group PT included cases where an intraarticular ACL reconstruction with bone patellar tendon graft performed with a transtibial technique.

All patients were involved in high-risk sports activity considered as follows: football, rugby, volleyball, basketball, skiing, or martial arts.

No patients reported rheumatologic disorders or associated malalignment.

All patients agreed to participate in the study and signed an informed consent form in accordance with the Declaration of Helsinki (1964).

The study meets the ethical standards of the journal (15).

Surgical technique

Group HT: Intra-articular reconstruction

An arthroscopically assisted anatomic single-bundle two incision technique using doubled Semitendinosus and

Gracilis tendons autografts was performed. Point of entry of the femoral tunnel was selected at the center of the anatomic femoral footprint of ACL, which was located midway between resident ridge and over the top position. A tibial tunnel was constructed with a standard guide at 65°, while femoral tunnel was drilled trough an outside-in technique. The tendons were also passed outside-in and manually tensioned before fixation. The bundles were fixed on the femur using the Swing Bridges device (Citieffe, Bologna, Italy) and on the tibia using the Evolgate device (Citieffe). A tight fit of the graft in the bone tunnel was aimed for in all patients.

Group HT+ER: Combined Reconstruction (McIntosh as Modified by Cocker Arnold in Addition to Intra-articular Reconstruction)

After the IR was fixed, the incision on the lateral side was extended to 10 to 12 cm in a hockey-stick fashion, extending from the Gerdy's tubercle proximally to just inferior to the lateral epicondyle while the knee was flexed to 90°. The proximal extent of this incision parallels the midportion of the iliotibial tract. The Fascia Lata was exposed and incised along its fibers about 3 cm from the posterior border. With 1 cm of the iliotibial tract left intact posteriorly, a 1-cm-wide and 13-cm-long strip of the iliotibial tract was detached proximally, leaving intact its distal attachment on the Gerdy's tubercle. The lateral collateral ligament was identified, and the proximal part of the strip was passed under the ligament; the band was then reflected on itself and sutured under tension with periosteal absorbable stitches to the Gerdy's tubercle while the tibia was held in maximal external rotation.

The strip was also sutured to the fibular collateral ligament for additional stability. A combined reconstruction required an additional surgical time of fifteen minutes.

Group PT: Intra-articular reconstruction with bone patellar tendon graft

The central third of the PT was harvested either through an open approach with a vertical incision. The tendon defect was sutured, and defects in the patella and the proximal tibia were not bone grafted. The bone blocks were sized at 10 or 9 mm. The tibial tunnel was drilled in the native ACL footprint. The femoral bone tunnels were created through transtibial drilling, aiming at the 10:00 to 10:30 clock position. The grafts were fixed on the femur using the Rigid Fix Cross Pin System (DepuySynthes) and on the tibial side using an absorbable screw (Biointrafix ACL fixation System, DepuySynthes). The knee was hyperextended, and firm traction was applied to the autograft before fixation of the tibial interference screw.

Postoperative rehabilitation

There was no difference in the rehabilitation protocol between the three groups: the involved knee was placed in a full extension brace for two weeks postoperatively with weight bearing with crutches as tolerated; daily isometric and isotonic exercises were prescribed. After wards, progressive range-of-motion exercises were encouraged as well as isometric and isotonic exercises. At four weeks postoperatively, full weight bearing without crutches and without brace was permitted. From the second month postoperatively, a heavier muscle-strengthening program was prescribed, and between four and six months a gradual return to athletic and sport specific training was encouraged. From the fifth month postoperatively, as soon as the trainer deemed patient "ready to go," full return to sports was allowed.

Follow up

A minimum of ten years follow-up examination was performed by the same observer who were independent (but not unaware because of the different scar in the three groups) and who were not involved in the initial surgery.

The activity level was assessed using the Tegner activity score(16). In evaluating the subjective functional status, the Lysholm score was used, whereas in evaluating the clinical outcome, the International Knee Documentation Committee (IKDC) rating system was used (17,18). Patients underwent a standardized bilateral knee examination.

Stability testing was performed using the Lachman test, the pivot-shift test, and the KT-1000 arthrometer (Medmetric, San Diego, CA).

Bilateral weight-bearing anteroposterior radiographs in full extension and lateral views were obtained and evaluated using the Fairbank scale, Kellgren-Lawrence scale, and IKDC grading system (18–20). Moreover, a skyline view was recorded to specifically evaluate patellofemoral joints according to the Kellgren score(20). Evaluation was performed by the same independent observer.

STATISTICAL ANALYSIS

Data were expressed in terms of mean and standard deviation of the mean. To evaluate differences between and among groups, One Way ANOVA have been performed.

For all tests $p < 0.05$ was considered significant. SPSS version18 was used for the calculations.

RESULTS

A total of sixty patients were included in the study (twenty for each group). All patients were male, involved in sport activities at the time of injury (Tegner pre-injury ≥7).

In group HT the mean age at surgery was 28,5 years (range 21 to 35 years). The mean follow-up time was 10 years and 5 months (range 121 to 128 months). A partial medial meniscectomy was performed in two patients, a partial lateral meniscectomy was performed in three patients, and a partial medial and lateral meniscectomy was performed in one patient. A subjective, clinical and radiologic evaluations were performed for all patients.

In group HT+ER the mean age at surgery was 28,7 years (range 19 to 35 years). The mean follow-up time was 10 years 6 months (range 122 to 130 months). A partial medial meniscectomy was performed in one patient, a partial lateral meniscectomy was performed in five patients, and a partial medial and lateral meniscectomy was performed in two patients. A subjective, clinical and radiologic evaluations were performed for all patients.

In group PT the mean age at surgery was 22,5 years (range 17 to 26 years). The mean follow-up time was 14 years 3 months (range 120 to 264 months).

A partial medial meniscectomy was performed in three patients, a partial lateral meniscectomy was performed in six patients, and a partial medial and lateral meniscectomy was performed in three patients. As for the two previous groups, also in this group subjective, clinical and radiologic evaluations were performed for all patients.

No major complication was reported after surgery in all groups. No patients reported rheumatologic disorders or associated malalignment.

Demographic data are summarized in **table I**.

Subjective evaluation

At final follow-up in group HT the mean Lysholm score was 97,74 (standard deviation [SD]= 2,78); IKDC subjective score was 96,77 (standard deviation [SD]= 3,47), and median Tegner activity score was 7 (range 3 to 8).

In group HT+ER the mean Lysholm score was 97 (standard deviation [SD]= 3,91); IKDC subjective score was 95,69 (standard deviation [SD]= 4), and median Tegner activity score was 6 (range 3 to 8).

In group PT the mean Lysholm score was 97,74 (standard deviation [SD]= 6,45); IKDC subjective score was 96,31 (standard deviation [SD]= 6,66), and median Tegner activity score was 9 (range 4 to 10).

No significant statistical differences were detected between the 3 groups in any subjective scores except for the Tegner score, in favor of group PT. ($p<0.05$)

Objective evaluation

In group HT, with respect to the IKDC objective score, 12/20 (60%) patients were in group A, 6/20 (30%) in group B, 2/20 (10%) in group C; there were no patients in group D.

In group HT+ER, for the IKDC objective scores, 13/20 (65%) patients were in group A, 6/20 (30%) in group B, and 1/20 (5%) in group C; there were no patients in group D.

In group PT, for the IKDC objective scores, 14/20 (70%) patients were in group A, 5/20 (30%) in group B, and 1/20 (5%) in group C; there were no patients in group D.

No significant statistical differences were detected between the three groups($p>0,05$).

Post-operative range of motion among the three groups was significantly different: PT group showed higher extension and flexion deficit compared the other two groups (2 patients in group PT [10%], and 0 in the groups HT and HT+ER) (**figure 1**).

Arthrometric evaluation

In group HT, instrumental laxity testing using a KT- 1000 arthrometer showed a mean side-to-side maximum manual (S/S MM) difference of 2,4 mm (SD = 1,56), with sixteen patients (65%) under 3 mm, six patients (30%) between 3 and 5 mm, and one patient (5%) more than 5 mm.

In group HT+ER, KT-1000 arthrometer evaluation showed a mean side-to-side maximum manual difference of 2,2 mm (SD = 1,29), with 15 patients (75%) under 3 mm, 5 patients (25%) between 3 and 5 mm, and no patient more than 5 mm.

In group PT, KT-1000 arthrometer evaluation showed a mean side-to-side maximum manual difference of 2,2 mm

Table I. Demographic data.

Table I	HT group (n=20)	HT+ER group (n=20)	PT group (n=20)
Age at surgery, years	28,5 (range 21-35)	28,7 (range 19-35)	22,5 (range 17-26)
Age at follow-up, years	38,9(range 31-45)	39,2 (range 29-45)	34,9 (range 25- 44)
Mean Follow-up, months	125(range 121 to 128)	126 (range 122 to 130)	171 (range 120 to 264)

Figure 1. Slight loss of flexion and extension in the PT group.

Table II. Clinical results. IKDC, International Knee Documentation Committee; M, mean; SD, standard deviation; S/S MM, side-to-side maximal manual.

Table II	HT group (n=20)	HT+ER group (n=20)	PT group (n=20)
Lysholm, M (SD)	97,7 (2,8)	97 (4)	96,4 (6,4)
IKDC subjective, M (SD)	96,8 (3,5)	95,7 (4)	96,3 (6,7)
Tegner (median)	6	7	9
IKDC objective			
A	12/20 (6O%)	13/20 (65%)	14/20 (70%)
B	6/20 (30%)	6/20 (30%)	5/20 (25%)
C	2/20 (10%)	1/20(5%)	1/20 (5%)
D	-	-	-
KT-1000 S/S MM, M (SD)	2,4 (1,6)	2,2 (1,3)	2,2 (1,3)
<3 mm	13 (65%)	15 (75%)	14 (70%)
3-5 mm	6 (30%)	5(25%)	5 (25%)
>5 mm	1 (5%)	-	1(5%)

(SD = 1,30), with fourteen patients (70%) under 3 mm, five patients (25%) between 3 and 5 mm, and one patient (5%) more than 5 mm.

A mean difference was detected in favor of groups HT+ER and PT, but this difference is not statistically significant (p>0,05).

Considering as a failure a presence of a side-to-side maximum manual difference of more than 5 mm using KT-1000 arthrometer or a pivot shift test as ++/+++, any giving way episode during follow-up period, and the revised case, we found 2 cases of failure in group HT and one case in the groups HT+ER and PT (p>0.05), with a trend in favor of HT+ER and PT groups. Clinical results are summarized in **table II**.

Radiologic evaluation

Radiologic results are summarized in **table III**, and **tables IV**, **V** and **VI** present the radiologic results of meniscectomized patients of groups HT, HT+ER and PT, respectively (**figures 2,3,4**).

The number of patients classified as C for IKDC radiographic score was significantly higher in group HT (2/20, 10%) and in the group PT (3/20, 15%) than group HT+ER (0/20, 0%) (p<0.05).

The number of patients included in grades II, III, and IV according to Kellgren classification (tibiofemoral joint) in group HT (7/20; 35%) was statistically higher than in group

Table III. Radiologic results. IKDC, International Knee Documentation Committee; K/L Kelgren Lawrence.

Table III	HT group (n=20)	HT+ER group (n=20)	PT group (n=20)
IKDC score			
Group A	12 (60%)	15 (75%)	11 (55%)
Group B	6 (30%)	5 (25%)	6 (30%)
Group C	2 (10%)	-	3 (15%)
Group D	-	-	-
Fairbank classification			
Grade I	10 (50%)	11 (55%)	9 (45%)
Grade II	7(35%)	7 (35%)	9 (45%)
Grade III	3 (15%)	2 (10%)	2 (10%)
Grade IV	-	-	-
K/L Classification			
Grade 0	3 (15%)	2 (10%)	7 (35%)
Grade I	9 (45%)	16 (80%)	5 (25%)
Grade II	4 (20%)	2 (10%)	6 (30%)
Grade III	3 (15%)	-	2 (10%)
Grade IV	1 (5%)	-	-
K/L Patellofemoral			
Grade 0	1 (5%)	7(35%)	6 (30%)
Grade I	11(55%)	10(50%)	3 (15%)
Grade II	6 (30%)	3(15%)	5 (25%)
Grade III	2 (10%)	-	5 (25%)
Grade IV	-	-	1 (5%)

Table IV. Meniscectomy Radiologic results Group HT. IKDC, International Knee Documentation Committee; K/L Kelgren Lawrence.

HT group (n=20)	Meniscectomized (n=5)	Nomeniscectomized (n=15)
IKDC score		
Group A	-	10 (50%)
Group B	2 (10%)	4 (20%)
Group C	1 (5%)	1 (5%)
Group D	2(10%)	-
Fairbank classification	1(5%)	6 (30%)
Grade I	1 (5%)	8 (40%)
Grade II	2 (10%)	1 (5%)
Grade III	1 (5%)	-
Grade IV		
K/L Classification		
Grade 0	-	3 (15%)
Grade I	2 (10%)	6 (30%)
Grade II	-	6 (30%)
Grade III	1 (5%)	1(5%)
Grade IV	1 (5%)	-

Table V. Meniscectomy Radiologic results Group HT+ER. IKDC, International Knee Documentation Committee; K/L Kelgren Lawrence.

HT +ER group (n=20)	Meniscectomized (n=5)	Nomeniscectomized (n=15)
IKDC score		
Group A	4 (20%)	11 (55%)
Group B	1 (5%)	4 (20%)
Group C	-	-
Group D	-	-
Fairbank classification	2 (10%)	8 (40%)
Grade I	3 (15%)	5 (25%)
Grade II	-	2 (10%)
Grade III	-	-
Grade IV		
K/L Classification		
Grade 0	-	2 (10%)
Grade I	5 (25%)	10 (50%)
Grade II	-	3 (15%)
Grade III	-	-
Grade IV	-	-

Table VI. Meniscectomy Radiologic results Group PT. IKDC, International Knee Documentation Committee; K/L Kelgren Lawrence.

PT group (n=20)	Meniscectomized (n=13)	Nomeniscectomized (n=7)
IKDC score		
Group A	2 (10%)	7 (35%)
Group B	5 (25%)	-
Group C	6 (30%)	-
Group D	-	-
Fairbank classification	2 (10%)	7 (35%)
Grade I	8 (40%)	-
Grade II	3 (15%)	-
Grade III	-	-
Grade IV		
K/L Classification		
Grade 0	2 (10%)	7 (35%)
Grade I	1 (5%)	-
Grade II	7 (35%)	-
Grade III	3 (15%)	-
Grade IV	-	-

HT+ER (2/20; 10%) (p<0.05), but not towards the group PT (p>0,05).

The number of patients included in grades II, III, and IV through Kellgren classification (patellofemoral joint) in group PT (11/20; 55%) was statistically higher than in groups HT (8/20; 40%) and HT+ER (3/20; 15%) (p<0.05). There was no statistically significant difference between groups through Fairbank classification.

In group HT, the number of meniscectomized patients categorized as C and D according to the IKDC radiographic score (3/5; 60%), was significantly higher than the number of nonmeniscectomized patients (1/15; 6,67%) (p<0.05).

Furthermore, also the number of meniscectomized patients included in grades III and IV through Fairbank classification (3/5; 60%) was significantly higher than that of nonmeniscectomized patients (1/15; 6,67%) (p<0.05).

In addition, the number of meniscectomized patients included in grades II, III, and IV via Kellgren classification (2/5; 60%) was not statistically different from that of nonmeniscectomized patients (7/15; 46%), (p>0,05).

No statistically significant difference was found in all scales comparing meniscectomized and non- meniscectomized patients of group HT+ER.

In group PT, the number of meniscectomized patients categorized as C and D according to the IKDC radiographic score was (6/13; 46,15%), while among nonmeniscectomized patients nobody is among these categories, showing statistically significant evidence among the groups (p<0.05).

The number of meniscectomized patients included in grades III and IV through Fairbank classification (3/13; 23,07%) was not statistically different from that of non- meniscectomized patients. (p>0,05) In addition the number of meniscectomized patients included in grades II, III, and IV via Kellgren classification (10/13; 76,92%) was significantly higher than that of nonmeniscectomized patients (0/7) (p<0.05).

The number of meniscectomized patients categorized as C and D according to the IKDC radiographic score in group HT (3/5; 60%) was higher than in group HR+ER (0/5), and group PT (6/13; 46,15%), showing a statistically significant difference only towards the group HT + ER. (p<0.05)

The number of meniscectomized patients included in grades III and IV according to Fairbank classification in group HT (3/5; 60%) was significantly higher than in group HT+ER (0/5), and group PT (3/13; 23,07%). (p<0.05)

No statistically significant difference was found comparing Kellgren classification (grades II, III and IV), in the different groups.

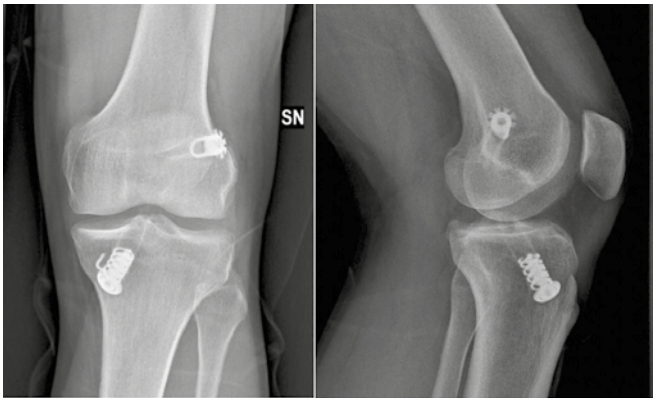

Figure 2. X-rays AP an LL an of ACL reconstructed knee in group HT.

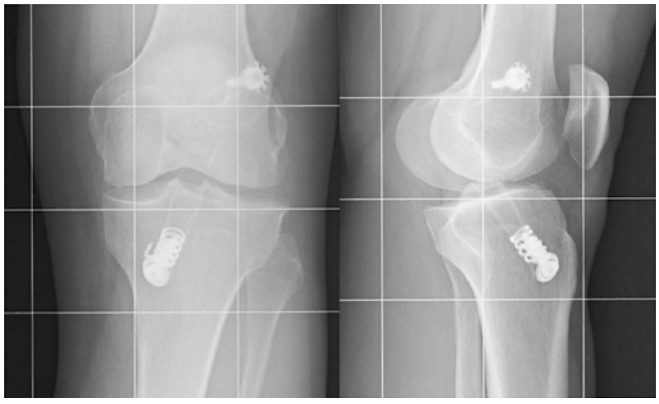

Figure 3. X-rays AP an LL an of ACL reconstructed knee in group HT+ER.

Figure 4. X-rays AP an LL an of ACL reconstructed knee in group PT.

DISCUSSION

This retrospective clinical and radiological study is a comparison between three different techniques for ACL reconstruction (HT, HT+ER and PT) at long-term follow-up (minimum follow-up 10 years.).

The most important finding of this study is that overall results with these surgical techniques were satisfactory and the majority of the patients could return to the same preoperative sports level.

Therefore, the primary hypothesis aforementioned was confirmed: there were no differences in knee laxity and clinical outcomes in ACL reconstructed knee adopting the three different techniques.

Our study has shown a difference comparing post-operative range of motion with two patients showing loss of extension or flexion in PT group, and for these reasons graded as B in the IKDC objective evaluation.

The secondary major finding of this study is the absence of significant differences between the three techniques in radiological evaluation. We only found a difference considering patello-femoral joint degeneration, as evaluated in Kellgren score, with an higher incidence in group PT (11/20 [55%]grades as II, III, IV), in respect to HT and HT+ER (8/20; [40%] and 3/20; [15%] respectively).

The evaluation of long term widening of the femoral and tibial tunnels was not a goal of the present study. As suggested by de Beus et al., correct evaluation of the tunnel widening after ACL reconstruction needs a careful evaluation using a CT scan (21). In this retrospective series of patients, we only performed X – rays at final follow up while we didn't perform a CT scan evaluation and for this reason, a careful evaluation of the widening of the tunnel wasn't possible. However, we should consider that several studies showed no correlation between tunnel widening and clinical results after ACL reconstruction (21–24). So, we can speculate that microinstability related to tunnel widening should have a negligible effect on the development of OA.

Considering the effectiveness of the three surgical techniques -without any pathology that could influence OA changes- several patients had a meniscectomy at the time of surgery, specifically, 5 meniscectomies in each groups HT, HT+ER, and 13 meniscectomies in group PT. Previous studies well documented the effect of meniscectomy on the development of OA after ACL reconstruction (25,26). In fact, we found higher incidence of post-operative OA in meniscetomized patients, respect to nonmeniscetomized. The effect of meniscal lesions and meniscectomy on the development of OA is well demonstrated in the literature, and we should consider that all the patients of the present study where operated in a chronic phase, where giving away episodes can lead to meniscal or chondral injuries (27). However, early ACL reconstruction to prevent or slow down the onset of degenerative changes and osteoarthritis had not been proven but we can expect a lower rate of meniscal tear in the patient who underwent early ACL reconstruction and subsequently a lower incidence of OA (28). Moreover, we included in this case only patients involved in high – risk sports activities that were operated for an ACL reconstruction and for this reason a comparison with coper patients treated conservatively wasn't possible (29). Another important point highlighted by the authors is the actual risk of over constraint of lateral reconstructions.

Since the eighties, when ER were very popular, this risk was considered. In the last few years, several medium and long term clinical and radiological studies have been reported as well as a level one review paper (8,11,30). All these studies concluded that there is no evidence that adding a lateral tenodesis to an anatomically placed hamstring ACL graft results in either an increased rate of osteoarthrosis or in a restricted range of motion or other over constraining related functional impairment.

The lack of difference of OA in 3 groups at final follow-up, seems to be in aligned with Devitt et al. (24).

Another aspect to be considered in a long-term follow-up study comparing difference techniques, is the incidence of failure rate. As previous reported in the literature we considered as a failure a presence of a side-to-side maximum manual difference of more than 5 mm using KT-1000 arthrometer or a pivot shift test as ++/+++, any giving way episode during follow-up period. Even if we did not report a significant difference in the failure rate between the three

groups, results demonstrated a trend with higher incidence in group HT (2/20 10%), in respect to the groups HT+ER, PT (both 1/20 5%). These results seem to be in accordance with other previous studies reporting that HT ACL reconstruction showed a higher risk of failure respect PT and HT+ER (6,11).Moreover, our results suggested that the addition of ER to HT graft reduces the failure rate, even if we had not found a statistically significative difference. However, the protective effect of ER as well as ALL reconstruction has been recently clearly demonstrated by biomechanical and clinical studies (9,31). We should consider that in this case series we only evaluated patients who underwent ACL surgery in a chronic phase, and an extraarticular tenodesis was added to an ACL reconstruction using HT. On the basis of our study, we cannot extrapolate results either on the effect of ALL repair in acute cases or the effect of ALL reconstruction (31). However, Sonnery – Cottet et al. showed similar results in a study where they compared 3 groups: 4HT; B-PT-B an HT + ALL reconstruction (10). They found that the rate of graft failure with HT+ALL grafts was 2.5 times less than with B-PT-B grafts and 3.1 times less than with 4HT grafts. The HT+ALL graft was found also associated with greater odds of returning to preinjury levels of sport when compared with the 4HT graft.

There is a lack in literature evaluating the effect of ER on PT graft. Recently Noyes et al. published a study showing a limited effect in the control of pivot shift phenomenon of an ACL reconstruction with PT with addiction of ER with iliotibial band (ITB). The findings of the study of Noyes and coauthors are in agreement with previously published studies performed by the same and other groups of researchers using a robotic apparatus apparently simulating a pivot shift (32).

These results are not surprising, because it is well-known that pivot shift is the effect of combined deficiency of two different structures (ACL and secondary restrains) acting as a single unit, as described by Terry et al. (33). In this sense, predictably, in an anatomically well-tensioned reconstructed ACL, a secondary lesion of the ALL (as in the Noyes and co. study) resulted in limited rotational instability and the following extraarticular reconstruction ineffective or, in the worst-case scenario, harmful.

Most of the recent studies concerning biomechanics and clinical evaluation of ER are related to their use along with intraarticular reconstructions with hamstrings. Similarly, the paper of Noyes and coauthors provide an original contribution to this topic as the PT reconstruction they evaluated is still widely used with excellent results.

However, there is a lack in literature of clinical studies evaluated the effect of ER on PT graft at long term follow up. Further studies are needed with the aim better understand possible advantages or risks of a permanent and harmful over constrain of the knee.

LIMITATIONS AND FUTURE RESEARCH

This study has several limitations. First of all, we evaluated a limited number of patients, only twenty for each group were available for radiological and clinical examination at final follow-up. However, patients were homogeneous in three groups in age, sex and participation in sport activity at time of surgery.

Secondly, the retrospective non-randomized design of this study might have influenced the results due to a selection bias. No preoperative X-ray could be analyzed and thus the progression of OA could not be estimated. The results of this study are not generalizable since confounding factors, such as cartilage damage, could not be analyzed in detail. However, we excluded patients with severe chondral lesions at the time of surgery, thus minimizing possible bias due to cartilage damage effect.

Lastly, another limit was that this was a multicentric study-even if all patients were operated by two expert senior authors in the same period. Moreover, different techniques were used for femoral tunnel drilling in the PT and HT groups (transtibial, and an out-in technique respectively), and different fixation device were used. These differences may be negligible with regard to long-term radiographic results.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

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