Comparison of Patellar Tendon and Hamstring Tendon Anterior Cruciate Ligament Reconstruction

A 15-Year Follow-up of a Randomized Controlled Trial

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Background: Numerous studies have compared patellar tendon (PT) and hamstring tendon (HS) anterior cruciate ligament (ACL) reconstructions in the short to midterm, but fewer long-term results have been published.

Hypothesis: There will be no difference in functional outcome between ACL reconstruction performed with PT and HS grafts, but PT grafts will have more donor site morbidity.

Study Design: Randomized controlled trial; Level of evidence, 1.

Methods: Sixty-five patients undergoing ACL reconstruction were randomized to receive either a PT graft or a 4-strand HS graft. Early results were reported at 4, 8, 12, 24, and 36 months. Forty-seven patients (22 of 31 PT and 25 of 34 HS) were reviewed at a mean of 15.3 years.

Results: Four graft ruptures (1 PT, 3 HS) and 6 contralateral ACL injuries (4 PT, 2 HS) occurred in the group that was reviewed. There was no statistically significant difference between the groups for any of the variables measured. There was a similar incidence of anterior knee pain and kneeling pain in both groups. The previously observed increased extension deficit in the PT group at 3 years was not present at 15 years, and there was no significant between-group difference in knee laxity. A higher proportion of patients in the PT group were participating in sport on a weekly basis (73% PT, 48% HS; $P = .05$). There was no difference in the degree of osteoarthritis between the groups.

Conclusion: This randomized controlled trial showed that HS and PT ACL reconstructions have comparable results at an average 15-year follow-up. Contrary to the study hypothesis, some of the graft differences seen at earlier review were not present at 15 years, and patients with PT grafts were more active in sport participation. Overall, both graft types provided good long-term subjective and objective outcomes.

Keywords: anterior cruciate ligament (ACL) reconstruction; long-term follow-up; patellar tendon; hamstring tendon

The choice of whether to use a patellar tendon (PT) or hamstring tendon (HS) graft for primary anterior cruciate ligament (ACL) reconstruction has been one of the most debated topics in the orthopaedic literature. Since the mid-1990s, numerous randomized controlled trials have been initiated to determine which graft offered a superior outcome. Recent years have seen many attempts at combining the results of these trials, and a variety of reviews and meta-analyses have been published.[6,7,9-11,25,30,32] Unfortunately, the methodology used in these review studies varied, and as a consequence, there are not only discrepancies in the findings but also contradictory recommendations.

To overcome some of the methodological limitations of the previous reviews, Mohtadi and colleagues[19] published a Cochrane review in 2011. Results of this review showed greater static knee stability but a loss of extension and increased anterior knee and kneeling pain with the use of PT grafts. HS grafts were associated with a loss of flexion range of motion and knee flexor strength. One important aspect highlighted by this review is the lack of long-term data. Indeed, of the 19 studies in the Cochrane review, only 7 (including 1 with 2 follow-up papers) reported longer term outcomes in their randomized cohorts, with follow-up ranging from 7 to 14 years.[1,4,5,12,18,24,27,31]

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The present study is a randomized 15-year follow-up study designed to compare the outcome of PT and HS primary ACL reconstruction. It is a follow-up of our previous 3-year study, which showed a greater incidence of kneeling pain and loss of extension in the PT group.[8] Our hypothesis was that these donor site differences would persist but similar results would otherwise be seen in the long term between the 2 graft types.

METHODS

From May 1996 to February 1998, a total of 65 patients who underwent primary ACL reconstruction by a single orthopaedic surgeon were randomized to receive either a central-third bone–PT–bone autograft (n = 31) or a doubled semitendinosus and gracilis tendon autograft (n = 34).

Inclusion criteria for the randomized trial were as follows: age 18 to 40 years, ACL rupture occurring >3 weeks but <12 months previously, no previous surgery performed on the affected knee, no previous cruciate ligament damage sustained in the affected or contralateral knee, no concurrent or residual collateral ligament injury of grade >2 severity, and no evidence of osteoarthritis on plain radiographs at the time of reconstruction. Patients were excluded if either (1) a chondral lesion of a severity greater than Noyes grade 2A[22] or (2) Noyes grade 2A lesions >1cm in diameter was seen at the arthroscopic examination performed at the commencement of the ACL reconstruction surgery. Patients were not excluded if a meniscal injury was found, so long as its treatment was such that it would not alter their rehabilitation.

For the current study at 15 years after surgery, we attempted to contact all patients; 47 of the original 65 were successfully contacted and agreed to participate. Local institutional board approval was given by a human ethics committee (application No. 11-083), and all patients signed consent forms.

Surgical Technique

Patients underwent an arthroscopically assisted single-incision ACL reconstruction. The PT grafts were harvested via an anterior longitudinal incision over the junction of the middle and lateral thirds of the PT, and the HS grafts were harvested via an oblique anteromedial incision over the distal attachment of the hamstring tendons. After identification of a suitable target point on the lateral wall of the intercondylar notch of the femur—at the 2- or 10-o'clock position per a clock face analogy—the femoral tunnel was drilled with a transtibial approach, consistent with common practice at the time that the study had commenced. Proximal fixation was by means of an EndoButton (Smith & Nephew Endoscopy) attached to the graft with a doubled 3-mm polyester tape. In the HS group, the distal 18 cm of each tendon was doubled, and the ends of each tendon were sutured over a distance of 3 cm with use of a No. 5 Ethibond (Ethicon Inc) whipstitch. No additional braiding of the tendons was used. The distal bone block of the PT graft was controlled with a No. 5 Ticron (Sherwood Medical) suture. The graft constructs were statically pretensioned at 89 N (20 lb) for at least 5 minutes before insertion. A mark was made on the PT grafts 35 mm proximal to the upper end of the distal bone block and the femoral tunnel drilled and the graft construct adjusted to align this mark with the aperture of the femoral tunnel. For the HS grafts, a mark was made 30 mm distal to the proximal end of the graft, and this mark was aligned with the articular margin of the femoral tunnel. Thus, there was a constant 30 mm of HS graft in the femoral tunnel but a variable length of PT graft. Tunnels were drilled to the same diameter as the respective ends of the graft.

The grafts were inserted through the tibial tunnel. After proximal fixation had been secured, manual tension was applied to the distal end of the graft and the knee taken through a full range of movement. The distal end of both graft types was fixed with the knee in 70° of flexion with firm manual tension being applied to the graft. The PT grafts were fixed with a cannulated metallic interference Silk screw (Smith & Nephew Endoscopy) inserted over a guide wire to prevent divergence. The HS grafts were fixed by tying the whiptstitched ends to an Acufex fixation post (Smith & Nephew Endoscopy). In the PT group, the PT defect was loosely closed with interrupted absorbable sutures. The donor sites on the patella and tibial tubercle were not formally bone grafted, although bone fragments from trimming of the graft were placed in the tibial tubercle defect. In both groups, low suction drains were inserted into the joint and into the subcutaneous layer. Patients were discharged from hospital within 48 hours of surgery.

Evaluation

Follow-up evaluations were performed at 4 months, 8 months, 1 year, 2 years, and 3 years postoperatively, and the results from these were published.[8] For the current 15-year follow-up, a single independent orthopaedic surgical fellow evaluated the patients using the same protocols previously described.[8]

Examination consisted of using the bulge test to categorize the presence of a knee joint effusion as *none, small, moderate*, or *large*. Passive knee flexion of both knees was recorded with a goniometer, with the patient in the lateral decubitus position. For comparative purposes, the deficit (in degrees) of the operated limb was used. Extension deficits were recorded via the method described by Sachs et al.[26] In this technique, the patient is positioned prone, and the difference in heel height is converted to an extension deficit in degrees by a formula based on the difference in heel height and the patient's height. This method records the deficit relative to the normal hyperextension of the contralateral limb rather than relative to an arbitrary 0°. Measurements of side-to-side differences in anterior tibial displacement were made with a KT-1000 arthrometer (MEDmetric Corp) at 134 N.

Patient-reported outcomes included the presence (yes/no) and severity (10-cm visual analog scale) of anterior knee pain and pain on kneeling. As for earlier evaluations, patients completed the Cincinnati knee score[21] and Cincinnati Sports Activity Scale.[20] The International Knee

Documentation Committee (IKDC) subjective knee score[13] and the Veterans RAND 12-Item Health Survey (VR-12) were added to the 15-year follow-up. The VR-12 is a measure of health-related quality of life from which a physical and a mental component summary score can be calculated (it is similar to the SF-12 but in the public domain, unlike the SF-12, which requires a user license).[14,15]

Posteroanterior and lateral plain radiographs were taken of the reconstructed knee. The posteroanterior radiograph was taken with the patient standing with the knee in 15° of flexion, and the lateral view was with the knee in full extension with the foot supported on a bolster. The Kellgren-Lawrence[16] classification for osteoarthritis was used, and gradings were made by both the senior orthopaedic surgeon and the orthopaedic fellow. Definite radiographic osteoarthritic changes were classified as Kellgren-Lawrence grade ≥2.

Data Management and Statistical Analysis

Patients who sustained a graft rupture were excluded from group analyses for the following outcomes: pain (anterior knee pain and kneeling pain), range of motion, laxity, effusion, and radiographic change (Figure 1). Patients who sustained a contralateral ACL injury were excluded from range of motion and laxity analysis, as these outcomes are designed to compare the reconstructed knee with a healthy contralateral knee. For other patient-reported outcomes (subjective IKDC, Cincinnati knee score, VR-12, and sports activity) the data were analyzed both for the entire cohort and with patients who sustained further ACL injury removed. A power calculation determined that there was 80% power to detect large effect sizes ($d \geq 0.85$) with alpha set to 0.05. This meant that the minimum differences that could be detected between the groups were as follows: a 10-point difference (SD, ±12) for the IKDC subjective and Cincinnati knee scores, a 5° difference in flexion (SD, ±5°), a 2° (SD, ±2°) difference in extension deficit, a 1.3-mm (SD, ±1.4 mm) side-to-side difference in anterior knee laxity, and a 5-point (SD, ±5) difference in the VR-12 subscales.

Data were analyzed with the Student t test or the Mann-Whitney U test to compare the 2 groups at follow-up. Contingency tables were used to calculate significant differences in the number of patients in each category, based on presence of anterior knee pain, presence of pain on kneeling, effusion, Cincinnati sports activity level, and radiographic change. Significance was set at $P < .05$.

RESULTS

Follow-up and Further Surgery

Rates of follow-up throughout the entire trial are shown in Figure 2. Forty-seven of the initial 65 (72%) patients were followed up at a mean of 15.3 years (range, 14-17 years). One patient had died, and the remaining patients were not able to be contacted. The demographics of the reviewed patients are shown in Table 1. There was 1 early (6 months) graft rupture in the PT group, which occurred in the setting of significant trauma, but no other ACL injuries in the initial 3-year period. Between 3 and 15 years, 3 patients in the HS group ruptured their ACL grafts, and there were 6 contralateral ACL injuries (4 PT, 2 HS). One PT patient who sustained a contralateral ACL injury also went on to rerupture the graft in the contralateral knee.

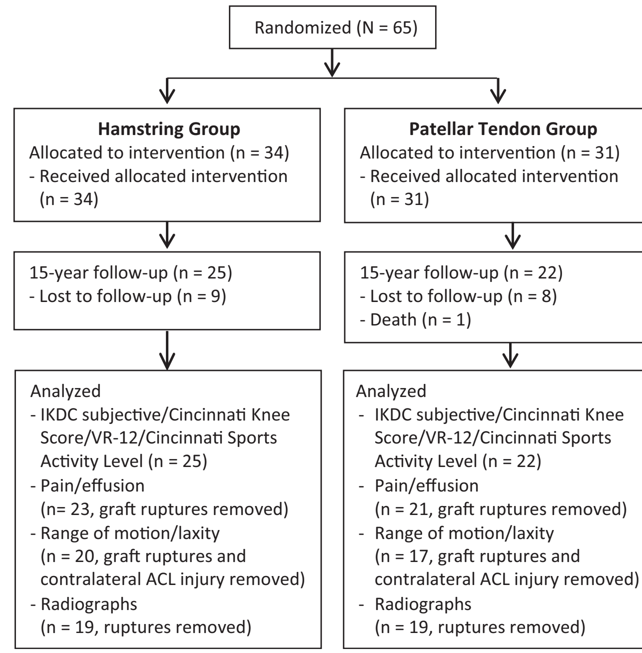

Figure 1. Participant randomization and analysis. ACL, anterior cruciate ligament; IKDC, International Knee Documentation Committee; VR-12, Veterans RAND 12-Item Health Survey.

Pain

Incidence of anterior knee pain throughout the trial is shown in Figure 3A. At 15 years, there was no difference between the 2 groups, and results were similar to the findings at 3 years. In those who reported anterior knee pain at 15 years, the severity of the pain was low (mean ± SD: HS, 2.3 ± 1.9 [range, 0.5-6]; PT, 2.6 ± 2.6 [range, 0.5-6]; 95% CI of mean difference, –3.2 to 2.7). Incidence of kneeling pain throughout the trial is shown in Figure 3B. At 15 years, the incidence of kneeling pain was similar between the groups, which was a change from earlier time points that had shown a significantly higher incidence in the PT group. In those who reported kneeling pain at 15 years, the severity of pain was low (HS, 2.3 ± 2.7 [range, 0.5-7]; PT, 3.0 ± 1.8 [range, 1-6]; 95% CI of mean difference, –2.8 to 1.4).

Range of Motion and Effusion

Extension deficits had been significantly greater for the PT group during the initial 3-year follow-up, but at 15 years, there was no difference between the groups, and any deficits had resolved (Figure 4). There had been no between-

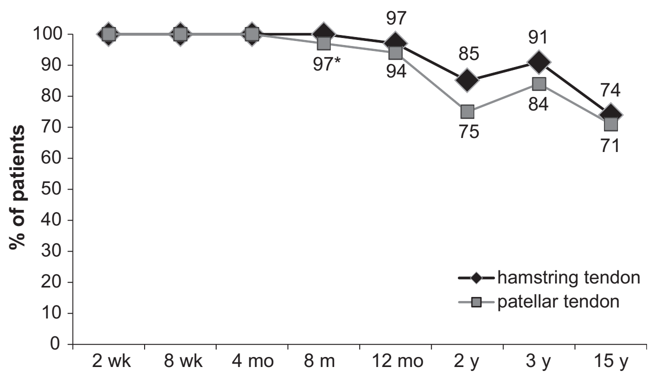

Figure 2. Percentage of patients followed up throughout the study. *1 patellar tendon graft rupture.

TABLE 1
Characteristics of the Study Cohort at 15-Year Follow-up[a]

Characteristic	HS Group (n = 25)	PT Group (n = 22)
Sex, male:female	20:5	16:6
Age, y		
At operation	26.1 ± 5.9	26.6 ± 6.7
At follow-up	41.3 ± 6.0	41.9 ± 6.7
Time from surgery to follow-up, y	15.2 ± 0.6	15.3 ± 0.4
Lesions at index surgery		
Chondral		
Patella	2	2
Trochlear groove	0	0
Medial femoral condyle	0	2
Medial tibial plateau	0	0
Lateral femoral condyle	0	0
Lateral tibial plateau	0	0
Medial meniscal injury and treatment		
Stable tear: no treatment	3	4
Partial meniscectomy	3	4
Repair	3	4
Lateral meniscal injury and treatment		
Stable tear: no treatment	0	2
Partial meniscectomy	6	5
Repair	0	1

[a]Values for continuous data are reported as mean ± SD; all other values are presented as No. of patients. HS, hamstring tendon; PT, patellar tendon.

group differences for passive knee flexion deficit at any earlier follow-up, and this remained the case at 15 years (mean ± SD: HS, 4.4° ± 5.3° [range, –5° to 15°]; PT, 2.9° ± 3.7° [range, –2° to 10°]; 95% CI of mean difference −1.7° to 4.6°). Mild effusions were present in more patients in the HS group than the PT group (42% vs 24%), but the difference was not statistically significant.

Anterior Knee Laxity

The PT group had smaller mean side-to-side differences in anterior knee laxity as compared with the HS group at every follow-up, but this was not significant at 15 years

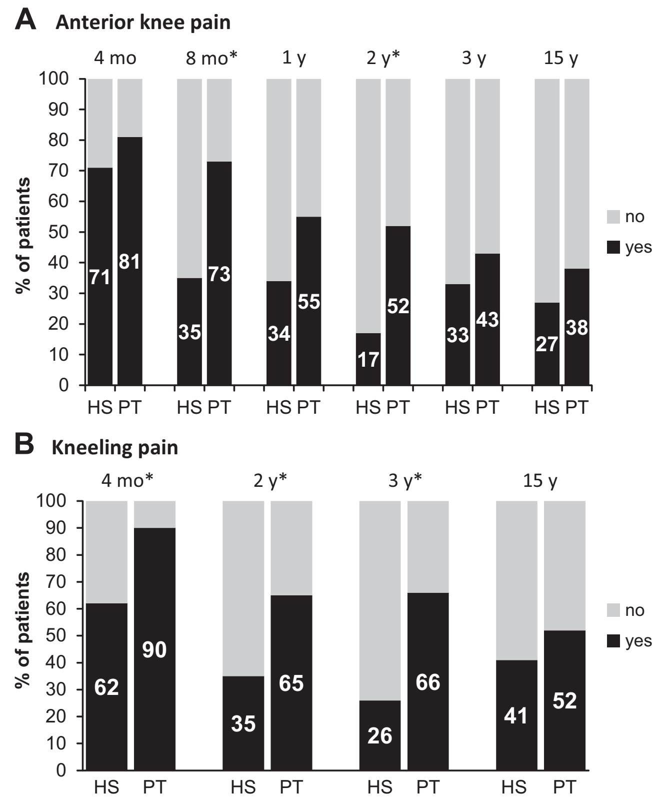

Figure 3. Incidence (%) of (A) anterior knee pain and (B) kneeling pain throughout the trial. HS, hamstring tendon group; PT, patellar tendon group. *$P < .05$, hamstring vs patellar tendon.

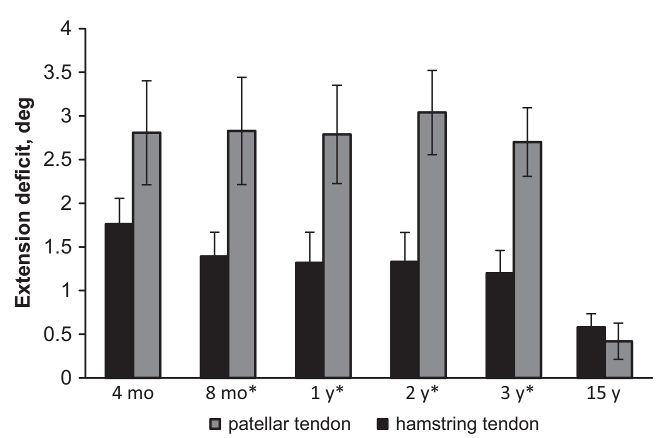

Figure 4. Extension deficits throughout the trial period. *$P < .05$, hamstring vs patellar tendon.

(mean ± SD: HS, 1.2 ± 1.3 [range, –1 to 4]; PT, 0.6 ± 1.5 [range, –2 to 4]; 95% CI of mean difference, –0.5 to 1.5) (Figure 5). Overall, both groups had stable knees, with average side-to-side differences <2 mm. At 15 years, 90% of patients in the HS group and 93% of patients in the PT group had a side-to-side difference ≤2 mm ($P = .6$).

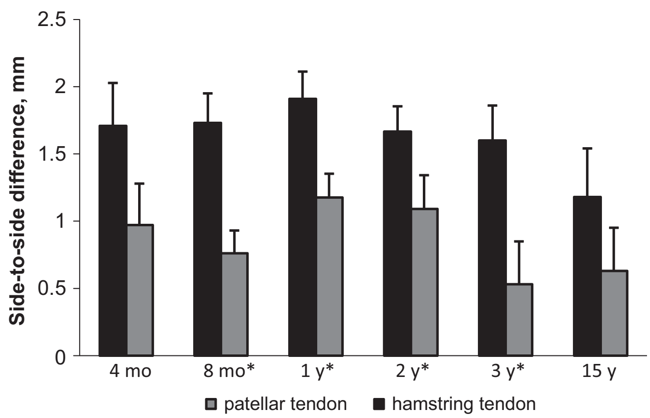

Figure 5. KT-1000 side-to-side differences in anterior knee laxity at 134 N throughout the trial. *$P < .05$, hamstring vs patellar tendon.

TABLE 2
Percentage of Patients With and Without Definite Radiographic Changes of Osteoarthritis at 15-Year Follow-up[a]

K-L Grade	HS Group (n = 19)	PT Group (n = 19)
0-1	68	74
2-3	32	26

[a]HS, hamstring tendon; K-L, Kellgren-Lawrence; PT, patellar tendon.

Radiographs

Radiographic changes of osteoarthritis were present in 50% (19 of 38) of patients, but of those with changes, 79% (15 of 19) were mild. We grouped patients according to those who had definite changes or not, and there was no difference between them (Table 2). None of the 3 HS patients with graft ruptures had radiographic changes, and the 1 PT patient who sustained an early graft rupture had grade 2 changes (these patients are not included in Table 2).

Cincinnati Knee Scores, IKDC Subjective Knee Scores, and Quality of Life

There were no differences between the 2 grafts in terms of Cincinnati or IKDC subjective scores at 15 years (Table 3). Health-related quality of life was also similar between the 2 grafts for physical and mental component summary scores (Table 3). Results were similar between the analysis that included the whole cohort who were reviewed at 15 years and a reduced cohort that excluded patients who sustained further ACL injury (either knee) during the study.

Sports Activity

Sports activity levels (based on frequency of participation) are shown in Table 4. At 15 years, a higher proportion of patients in the PT group were participating in sport on a weekly basis (level 1 or 2 frequency). This difference approached significance for the analysis that included all patients who were followed up (HS, 48%; PT, 73%; $\chi^2[1] = 3.81$, $P = .05$). Two of the 4 patients who sustained a graft rupture (both HS) and 5 of the 6 patients (4 PT, 1 HS) who sustained a contralateral injury were still participating in sport at 15 years. For those patients who were still playing sport, the type of sport in which they participated is also shown in Table 4.

DISCUSSION

The aim of this study was to compare the long-term results (15-year follow-up) from a randomized controlled trial of PT and HS ACL reconstructions. Overall there were no significant differences between the 2 graft types for a range of outcomes, and both showed successful long-term results. Differences that were apparent between the 2 grafts at an earlier, 3-year follow-up were no longer apparent at 15 years, and our hypothesis that there would be greater donor site morbidity in the PT group was not supported.

The Cochrane review (in which only 32% of the studies had >3-year follow-up) reported a loss of extension range of motion for PT grafts.[19] We also previously showed a loss of extension range of motion in our PT group at up to 3-year follow-up.[8] This deficit had, however, all but resolved at the 15-year follow-up. Although the mechanism is unclear, this finding is consistent with those of other longer-term randomized controlled trials[1,4,18,27,31] but is contrary to the report by Leys et al.[17] Their 15-year follow-up of a prospective but nonrandomized trial found a significantly greater extension deficit rate in the PT group (21% PT vs 6% HS). The clinical relevance of any loss of range of motion has not been fully determined, and Leys et al[17] did not find any correlation between loss of extension and other clinical outcomes, even though it has been suggested that a reduced range of movement may combine with other risk factors for the development of osteoarthritis.[28,29] It is also worth noting that in this study, extension deficits were relatively small (<3°) throughout the study period and that larger deficits may not resolve to the same extent.

Pain on kneeling has also shown consistent differences between the 2 graft types and has generally been more problematic for PT grafts. Our current findings show the incidence and severity of kneeling pain to be similar between the groups at 15 years, and this is again a change from earlier reviews in which the incidence of kneeling pain was significantly greater in the PT group. Overall, the results of studies that reported kneeling pain at long-term follow-up are mixed, with some showing no difference[12,18,27] and others reporting persistent problems for PT grafts.[4,31] It is worth noting that even in studies that reported no difference between the 2 grafts, the overall incidence of kneeling pain is relatively high. For example, in the current study, it was around 50% for both graft types. Sajovic et al[27] reported a 30% and 48% incidence of pain with either strenuous or kneeling activities in their HS and PT groups, respectively, at an 11-year follow-up.

TABLE 3
Cincinnati Knee Scores, IKDC Subjective Knee Scores, and VR-12 Component Summary Scores at Follow-up[a]

Score	All Patients Followed Up at 15 y			Patients With Graft Rupture/ Contralateral ACL Injury Excluded		
	HS Group (n = 25)	PT Group (n = 22)	95% CI	HS Group (n = 20)	PT Group (n = 17)	95% CI
Cincinnati knee	85.3 ± 15.1	88.7 ± 11.6	−13.7 to 2.8	84.0 ± 15.5	88.2 ± 11.6	−13.5 to 5.1
IKDC subjective	84.4 ± 13.5	88.1 ± 12.3	−13.3 to 3.1	83.7 ± 14.6	86.8 ± 13.1	12.5 to 6.2
VR-12 component						
Physical	54.7 ± 3.8	53.2 ± 6.6	−1.6 to 5.1	54.5 ± 4.0	52.4 ± 7.2	−1.7 to 6.0
Mental	55.6 ± 5.9	53.1 ± 9.1	−3.1 to 4.1	56.0 ± 6.0	55.0 ± 6.0	−3.0 to 5.0

[a]Values are presented as mean ± SD and 95% CI of mean difference. ACL, anterior cruciate ligament; HS, hamstring tendon; IKDC, International Knee Documentation Committee; PT, patellar tendon; VR-12, Veterans RAND 12-Item Health Survey.

TABLE 4
Sports Activity Levels by Frequency and Type[a]

Level[b]	All Patients Followed Up at 15 y		Patients With Graft Rupture/ Contralateral ACL Injury Excluded	
	HS Group (n = 25)	PT Group (n = 22)	HS Group (n = 20)	PT Group (n = 17)
Frequency				
1 (4-7 d/wk)	20	5	20	6
2 (1-3 d/wk)	28	68	30	70
3 (1-3 times/mo)	20	9	20	6
4 (no sport)	32	18	25	18
Type of sport[c]				
1 (jumping, hard pivoting)	18	44.5	14	50
2 (running, twisting)	59	44.5	64	43
3 (no running)	23	11	22	7

[a]Values are reported as percentage of patients. ACL, anterior cruciate ligament; HS, hamstring tendon; PT, patellar tendon.
[b]Levels defined according to Noyes et al.[20]
[c]Only patients who reported playing sport were included in the analysis by type of sport.

While the incidence of kneeling pain may be relatively high, the severity of the pain may be more modest. In the current study, the mean severity was only 2.3 and 3 on a 10-point scale (or 23 and 30 on a 100-point scale) for HS and PT groups, respectively. This is similar to what we reported at the 3-year follow-up and to the severity reported by Holm et al[12] of 29 and 39 (on a 100-point scale). It is therefore unlikely that these levels of pain would limit activity, but this has not been specifically reported.

Differences in knee laxity had also resolved at the 15-year follow-up in the current study. This is consistent with all other studies reporting long-term laxity in both randomized and nonrandomized trials. Most of these studies, like ours, did report slightly increased laxity with the use of hamstring tendon grafts but failed to achieve statistical significance, and the small differences that are present are unlikely to be clinically relevant.[1,12,24,27]

Returning to sport after ACL reconstruction has been a topic of recent attention and follows from reviews that showed somewhat modest rates of return in this patient group.[2,3] In the current study, we used the Cincinnati Sports Activity Scale, in which sport participation is determined by the frequency of participation and type of sporting movements. Overall, 68% to 82% of patients were participating in some form of sport at 15 years, and there was a trend for the PT group to be participating more frequently than the HS group and to engage more in sports that involve cutting and pivoting. It is difficult to compare these results with those of other long-term follow-up studies, as sports activity has been measured in a number of ways. In a nonrandomized 15-year follow-up, a significantly higher proportion of HS patients reported undertaking strenuous activities.[17] However, in randomized controlled trials similar to ours, no between-group differences have been reported. Holm et al[12] reported that at 10-year follow-up, 46% of the HS group and 54% of the PT group had returned to their preinjury sport and that both groups had participated in this sport for approximately 5 years. Sajovic et al[27] reported that 81% of HS and 72% of PT patients were still at their preinjury levels at 11 years (70% and 64%, respectively, had played level 1 cutting/pivoting sports before injury). All long-term studies utilizing the Tegner sports activity scale show no difference between HS and PT groups.[4,12,18,31] Overall, it is likely that the subtle differences that have been reported may relate more to differences in patients' sporting desires rather than graft choice.

Similar to most authors of long-term randomized trials, we found no difference in the prevalence of tibiofemoral osteoarthritis between HS and PT groups.[1,5,12,24,31] This does, however, contrast with the randomized trial of Sajovic et al,[27] which reported a significantly higher prevalence of osteoarthritis in the PT group at 11 years. In addition, in a nonrandomized trial, Leys et al[17] showed a significantly higher prevalence of osteoarthritis in their PT group at 15 years. The long-term results are therefore mixed.

In the current study, the rates of osteoarthritis were notably low in both groups, this despite our inclusion of all meniscal injuries (provided treatment did not interfere with rehabilitation). This is perhaps surprising given that Barenius et al[5] found meniscal resection to be a strong risk factor for osteoarthritis in their randomized trial and that the association between meniscal resection and osteoarthritis has been well documented in the wider literature.[23] Our low rate of osteoarthritis may therefore be in part due to the strict inclusion criteria used in terms of the articular surface (ie, no changes >50% in depth).

A number of limitations need to be considered. Patient follow-up was incomplete, and the overall follow-up rate at 15 years was <80% (72%). The rates of follow-up were, however, similar for both graft types. The sample size is relatively small but was planned to be sufficient to identify differences between the groups with a large effect size. We believe that the differences that the study was powered to detect were of a sufficient magnitude to reflect clinical importance. Nonetheless, differences of a moderate to small effect size may have been present but not detected, leading to type 2 errors. In this context, it is relevant to note that most of the outcome variables had only small differences between the group means. Power calculations showed that the sample sizes needed to detect statistically significant differences—which would have been small in magnitude and potentially not clinically meaningful—would have needed to be between 300 to 500 patients. This is far greater than any similar randomized trial that has been published to date.

Two different tibial fixations were used. Ideally, the same tibial fixation would have been used for both graft types. However, at the time that the study commenced, interference screw fixation of HS grafts was a relatively new concept and not supported by the published literature. With a tibial fixation post in the HS group, suspensory fixation was used at both ends of the graft, compared with only 1 end in the PT group. Whether the increased graft laxity seen in the HS group up to 3 years was related to the fixation method or the intrinsic properties of the HS grafts is unclear. There were also few female participants in the patient cohort, which reduces the overall external validity of the study. Strengths of the study are the randomized design, strict inclusion/exclusion criteria to minimize variables that might confound the results, and the multiple and long-term follow-ups.

CONCLUSION

Long-term follow-up of our randomized controlled trial showed little differences between HS and PT grafts at 15 years for a variety of clinical outcome and patient-reported variables. Differences in donor site morbidity that were identified at earlier follow-up were not present at 15 years, and patients in the PT group tended to participate more frequently in sports. The results of the current study substantiate previous reports showing that excellent results may be obtained with either PT or HS grafts for the majority of patients.

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