Patellar Versus Hamstring Tendons in Anterior Cruciate Ligament Reconstruction: A Meta-analysis

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Purpose: To compare the outcome of ACL reconstuction using patellar tendon (PAT) to that when using hamstring tendons. **Type of Study:** Meta-analysis of controlled trials of patellar tendon versus hamstring tendons for ACL reconstruction. **Methods:** Meta-analysis is a systematic method for statistical analyses that allows compilation of combined data from various independent studies. This allows one to assess the potential benefits of various treatments when conclusions based on individual studies are difficult to assess. We conducted a meta-analyses (M-A) using controlled trials (CTs) to determine if there are differences between the 2 methods. Although both surgical techniques have potential for good results, we hypothesized that there are differences in outcomes between these techniques. We included CTs that used standard evaluation techniques with a minimum 2-year follow-up. Outcomes evaluated included: return to preinjury level of activity, KT testing, Lachman scores, pivot shift scores, range of motion (ROM) loss in flexion and extension, complications, and failures. Relative risks for each outcome were calculated for each study and pooled across studies using a fixed effects method. **Results:** Four studies fulfilled our inclusion criteria. Relative risks with 95% confidence intervals and *P* values were obtained for each of the outcomes listed above. The results show significant differences between PAT and semitendinosus and gracilis tendon (ST&G) reconstructions. PAT patients have a greater chance of attaining a statically stable knee (as measured by KT) and nearly a 20% greater chance of returning to preinjury activity levels. **Conclusions:** Although both techniques, as performed in the late 1980s and early 1990s, yielded good results, PAT reconstuction led to higher postoperative activity levels and greater static stability than hamstring reconstruction. This is statistically significant based on this meta-analysis. **Key Words:** Anterior cruciate ligament—Meta-analysis—Hamstring—Patellar—Reconstruction—Tendon.

The anterior cruciate ligament (ACL) is commonly torn in athletes of all ages. The treatment for a torn ACL has evolved over the past 3 decades from palliative treatment to arthroscopic reconstruction.[1,2] Surgical intervention has proven beneficial to the patient in terms of both pain and the ability to return to an activity level equal to preinjury.[3-5] The surgical interventions have matured over time, from large open incisions and repair to arthroscopically assisted reconstructions.[6,7] Currently, the 2 most widely preferred techniques for the arthroscopically assisted ACL reconstructions employ autologous semitendinosus and gracilis tendon (ST&G) or the central third of the patellar tendon (PAT).[7] The 2 techniques differ in the harvest of the graft as well as in the mechanism of securing the graft. The current literature does not clearly identify differences in these procedures in regard to outcome; thus, surgeons typically perform either operation based on their preference.[8] Of those physicians who perform both techniques, most believe that a certain patient population would benefit more from one method.

Ideally, a multicentered, randomized, controlled

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trial between these 2 methods would be performed. Unfortunately, this is very difficult.[9,10] There have been several studies in the orthopedic literature comparing the ST&G and the PAT techniques.[11-17] The method of graft harvest, preparation, and fixation varies somewhat between studies; however, the methods were consistent within the individual studies. Several of these individual studies have shown trends that were not statistically significant. These trials contained relatively few patients, which makes it difficult to find statistical significance even if important differences do exist.

In an effort to clarify the surgical results of autologous ACL reconstruction, we undertook a meta-analysis (M-A) of trials comparing PAT with ST&G. M-A allows one to systematically examine published studies in this area, assess their methodologic quality, and, where appropriate, pool their results together to obtain more precise estimates for the differences in outcomes.[18-20] Although both surgical techniques might provide excellent results, we hypothesize that there are important differences in outcome.

METHODS

Literature Search

We searched the published literature using the MEDLINE database (1980 to May 1997) for studies comparing ST&G with PAT for ACL reconstruction. We used the following subject headings and text words: anterior cruciate ligament, surgery, reconstruction, human. We restricted the included studies to those published in English. Abstracts were reviewed and assessed for relevance. We screened potential articles and conducted a manual reference search based on references identified in the individual papers. In addition, we performed a manual search of current research and unpublished literature.

Selection of Studies

We included all controlled studies that compared ST&G with PAT for ACL reconstruction. We required that data be provided to assess the subjective and objective postoperative condition of the graft and the patient. The inclusion criteria required that the patients be followed-up postoperatively through the protocol of the examiner for a minimum of 2 years. Studies also had to include an assessment of the ability to return to preinjury level of activity.

Studies that met the inclusion criteria were subsequently excluded if, on review of data presented in the paper, there were discrepancies in the methods or results section. In addition, studies were excluded if they did not provide adequate postsurgical data, such as laxity or subjective evaluation. On final assessment, reports by O'Neill et al.,[13] Aglietti et al.,[12] Marder et al.,[14] and Corry et al.[21] fulfilled our criteria and were included in this study (Table 1).

Data Extraction

Outcome criteria were defined as performance level, KT arthrometer measurements, Lachman scores, pivot shift results, range of motion (ROM) studies, complications, and failures. The postoperative

TABLE 1. *Patient Characteristics*

Study	Country/Year of Publication	No. Patients Enrolled (PAT/ST&G)	No. Patients Evaluated (PAT/ST&G)	Assignment Method	PAT Patient Gender (M/F)	ST&G Patient Gender (M/F)	PAT Mean Age (Range)	ST&G Mean Age (Range)
O'Neill et al.[13]	USA/1996	85/40	85/40	Birth date assignment	54/31	27/13	26 (15-49) 28 (14-56)†	27 (14-56)
Aglietti et al.[12]	Italy/1994	30/30	30/30	Alternating sequence	No data	No data	Range from skeletal maturity to 35 y	Range from skeletal maturity to 35 y
Marder et al.[14]	USA/1991	40/40	37/35	Alternating sequence	24/13	26/9	21.6 (16-35)	23.8 (17-41)
Corry et al.[21]	Australia/1999	90/90	77/77*	Sequential patients	48/42	47/43	25 (15-42)	25 (13-52)

* 77 patients in each group were available for follow-up evaluation of all tests with the exception of KT testing. Only 61 patients were available in the PAT group and 75 in the ST&G group for KT testing.

† This study separated the PAT technique into single- and double-incision techniques.

results were collected at follow-up dates determined by the individual investigators and were not stratified in each study.

Return to Preinjury Level of Activity

Two studies, O'Neill et al.[13] and Marder et al.,[14] directly reported return to preinjury level as a follow-up assessment. Aglietti et al.[12] reported results for return to preinjury level of athletic participation in strata. Only those patients who were reported as returning to the same sport were identified in our analysis as returning to the preinjury level of activity. Corry et al.[21] identified preinjury and postinjury level of activity on a scale of 1 to 4. The 2-year follow-up data were used for those subjects practicing (Level I) strenuous preinjury activity.

KT

Laxity testing using a KT arthrometer is a function of the force applied. O'Neill et al.[13] tested laxity using maximum manual force that is roughly equivalent to 30 lbs. Aglietti et al.[12] used a range of forces including 20 lbs, 30 lbs, and maximum manual. Marder et al.[14] and Corry et al.[21] used only 20 lbs (89 N). Corry et al.[21] reported KT laxity data for only 61 of the PAT group and 75 of the ST&G group. We were unable to include all 4 studies in any one analysis; therefore, we completed 2 separate analyses for KT data, using both maximum manual force and 20 lbs.

Lachman

Two separate analyses were completed using Lachman = zero and Lachman $\leq$1, for those studies in which Lachman data were available. O'Neill et al.[13] presented side-to-side difference using Lachman testing as scores of zero, $\leq$1, or $>$1. Marder et al.[14] reported postoperative Lachman grades of zero, 1+, 2+, 3+, or 4+. Corry et al.[21] reported Lachman test results as grades of zero, 1, or 2. Aglietti et al.[12] reported no Lachman data.

Pivot Shift

Two separate analyses were completed using pivot shift = zero and pivot shift $\leq$1. O'Neill et al.[13] did not report pivot shift data. Marder et al.,[14] Aglietti et al.,[12] and Corry et al.[21] all reported pivot shift data as grade zero, 1, 2, or 3.

Loss of ROM (Extension)

The reported loss of ROM differed among the 4 studies. At the time of the individual investigations, there was no standard for reporting ROM, each study used a different range, making direct comparison difficult. To enable comparison, and because any loss of ROM is relevant, we used only the minimum value presented in each study: 2° for O'Neill et al.,[13] 1° for Aglietti et al.,[12] greater than zero degrees for Marder et al.,[14] and greater than 3° for Corry et al.[21]

Loss of ROM (Flexion)

The studies maintained the same criteria for ROM loss in flexion; thus, we used the same criteria for comparing loss of flexion: 2° for O'Neill et al.,[13] 1° for Aglietti et al.,[12] greater than zero degrees for Marder et al.,[14] and greater than 3° for Corry et al.[21]

Complications

For the purposes of this analysis, a complication was considered any problem or reoperation of the ipsilateral knee. Failures were not included in the complications analysis, but were analyzed separately.

Failures

Each article reported failures as atraumatic or traumatic rerupture. Analysis was completed using the total number of patients evaluable at the conclusion of the study.

Data Analysis

For each trial and outcome of interest, we created a 2×2 table comparing the proportion of individuals in each arm with the outcome. We thereby calculated relative risks and their 95% confidence intervals, comparing those undergoing the PAT procedure with those receiving the ST&G procedure. Before pooling these relative risk estimates across trials, we calculated a Q-statistic for each outcome to check whether the relative risks were constant across trials. It is important to check for statistical heterogeneity among the results of individual trials using this statistic; if heterogeneity is present, it might indicate that it is inappropriate to pool the estimates from the studies. If the trials all have similar risk ratios, this statistic follows a χ-square distribution with degrees of freedom one less than the number of trials.[22] When the *P* value for this Q-statistic was less than .10, indicating heterogeneity, we examined the study reports for possible explanations. For each outcome with a constant relative risk, as outlined in the Q-statistic, we obtained pooled relative risk estimates using a fixed effects model.[24] If the relative risk was not constant, we did

not pool relative risks at all. The difference in outcome between PAT and ST&G was considered statistically significant if the 95% confidence interval for the relative risk did not encompass one.

We also wanted to determine how these relative risks translated into absolute difference. To do this, we first calculated the average risk for each outcome for patients undergoing ST&G by using a random effects model to combine (after a logit-transformation) the individual trial estimates of the risk in the ST&G groups.[24,25] Using the random effects model, we took into account the variable absolute risks in each group to get a pooled average risk. The average absolute frequency for each outcome in the PAT group was then determined by the product of the frequency in the ST&G group and the relative risk of each outcome in the PAT group. Finally, from these 2 absolute risks we calculated the risk difference. For our calculations we used the computer program Meta Analyst v.0.989 (J. Lau).

RESULTS

Literature

We identified 1,676 articles on our initial MEDLINE search of articles relating to ACL. Adding a subject heading of surgery, restricting our search to English language publications, and narrowing our focus using text words reduced our number of articles to 594. Only 3 of these fulfilled our requirement as controlled trials that included the necessary outcome data. These were O'Neill et al.,[13] Aglietti et al.,[12] and Marder et al.[14] An additional article, Corry et al.,[21] was identified by the senior author in an ongoing search of current research and unpublished studies.

Patient Characteristics

There were a total of 424 patients in the 4 studies. Of these, 234 underwent ACL reconstruction with the PAT autograft and 190 underwent ACL reconstruction using the ST&G autograft. Table 1 describes the individual studies and the patient population enrolled in each. Gender information was provided by 3 of the studies. O'Neill et al.[13] enrolled 54 men and 31 women in the PAT group. The ST&G group included 27 men and 13 women. This study broke down the PAT patients into 2 groups based on PAT technique. For the purposes of this M-A, these 2 groups were pooled. Aglietti et al.[12] provided no gender information on either group. Marder et al.[14] enrolled 24 men and 13 women in the PAT group, whereas the ST&G group included 26 men and 9 women. The fourth study, by Corry et al.,[21] included 48 men and 42 women in the PAT group. The ST&G group contained 47 men and 43 women.

Patient ages were described by 3 of the 4 studies (Table 1). The mean age and range for the 2 PAT groups in O'Neill et al.[13] were 26 (15 to 49) and 28 (14 to 56). The ST&G group mean was 27 years with a range of 14 to 56. Aglietti et al.[12] stated only that patients in both groups ranged from skeletal maturity to 35 years. The mean ages and ranges for PAT and ST&G in the study by Marder et al.[14] were 22 (16 to 35) and 24 (17 to 41), respectively. Means and ranges for PAT and ST&G in the study by Corry et al.[21] were 25 (15 to 42) and 25 (13 to 52), respectively.

Surgical Procedure

The surgical technique was different in each of the studies, although they were consistent within each study (Table 2). O'Neill et al.[13] performed both a single and double incision technique on the PAT patients. The bone-tendon-bone grafts in both cases were fixed with interference screws in the femur and tibia. The ST&G procedure was 2-stranded, using 2 medium barbed staples each to secure the ST&G graft to the tibia and lateral femoral cortex. Aglietti et al.[12] used suture around a screw to secure the PAT bone-tendon-bone graft to the femur. The tibial attachment was fixed with an interference screw. The ST&G technique was 4-stranded. The graft was secured on the femoral side with a cortical screw and ligament washer. The tibial side was fixed with sutures around a post. Marder et al.[14] used a post and washer for both ends of the PAT bone-tendon-bone graft, as well as the both ends of the double-looped ST&G graft. Corry et al.[21] used a metal interference screw on both ends of the PAT bone-tendon-bone graft as well as both ends of the doubled ST&G graft.

Postoperative Treatment

The postoperative management of the patients in these studies varied among the studies, but was consistent in the individual studies. O'Neill et al.[13] allowed full weight bearing on postoperative day 1 with full motion. Closed kinetic chain exercises were allowed at 6 weeks and running at 3 months. No crutches or assisted devices were used after week 1, and the patient was allowed to return to full activity at 6 months. Aglietti et al.[12] splinted all patients for 1 month with removal of the splint for ROM exercises 1 to 2 times each day. Patients were allowed to bear full

TABLE 2. *Operative and Postoperative Procedure*

Study	PAT Procedure	ST&G Procedure	Postoperative Technique
O'Neill et al.[13]	Single incision technique: bone-tendon-bone graft, secured using an interference screw in the femur and tibia Double incision technique: bone-tendon-bone graft, secured using an interference screw in the femur and tibia	Femoral: Semitendinosus and gracilis tendons secured to lateral femoral cortex using 2 medium-barbed staples Tibial: ST&G tendons secured to the tibia using two medium barbed staples, ST&G tendons sutured together and double looped	Full weight bearing postoperative day 1 with full motion allowed. Closed kinetic chain exercises at 6 weeks. No crutches or assisted devices after week 1. Running at 3 mo. Return to activity at 6 mo.
Aglietti et al.[12]	Femoral: bone-tendon-bone graft, secured by press fitting of fragment, 4 sutures tied over cortical screw and washer Tibial: interference screw	Femoral: Cortical screw and plastic washer Tibial: sutures over cortical screw and washer	Splint with active flexion on day 2. Splint worn for 1 mo but was removed 1-2 times per day. Protected weight bearing on day 3. Full weight bearing after 2 mo. No leg extension against resistance before 6 mo. Cutting sports at 7-8 mo.
Marder et al.[14]	Femoral: bone-tendon-bone graft, secured using post and washer Tibial: post and washer	Femoral: ST&G graft doubled, secured using post and washer Tibial: post and washer	Immobilized at 40° flexion with passive extension and active flexion 3 times per day. Stationary cycling at 4 weeks. Full weight bearing without brace at 6 wk. Active knee extension at 6 mo. Functional derotation device advised with full activity.
Corry et al.[21]	Femoral: bone-tendon-bone graft secured using RCI screw Tibial: secured using RCI screw	Femoral: ST&G graft doubled, secured using RCI screw Tibial: secured using RCI screw	Immediate weight bearing, no brace. Active ROM exercises by day 14. Strengthening at 12 wk. Return to activity at 9 mo.

Abbreviations: PAT, patellar tendon; ST&G, semitendinosus and gracilis tendon; RCI, round-headed cannulated interference.

weight by the end of the second month, but were not allowed to perform any leg extension against resistance before 6 months. Cutting sports could be resumed at 7 to 8 months. Marder et al.[14] immobilized the patients with the knee flexed at 40°, allowing passive extension and active flexion 3 times per day. Bearing of full weight was allowed at 6 weeks and active knee extension exercises were allowed at 6 months. Upon return to full activity, a functional derotation device was recommended. Corry et al.[21] allowed immediate weight bearing with active ROM exercises by day 14 and strengthening at 12 weeks. Patients were allowed to return to regular activities at 9 months.

Outcomes

Return to Preinjury Level of Activity: For the outcome "return to preinjury level of activity," all 4 studies suggested that PAT was better than ST&G, although statistical significance was reached in only one.[21] The combined results show that a person undergoing ACL replacement using the PAT graft has an 18% greater chance of returning to preinjury level of activity ($P = .01$). The estimated absolute percentage of ST&G patients who would return to preinjury level of activity is 64%. The PAT patients had an estimated 75% return to preinjury level of activity, an absolute difference of 11% (Table 3, Fig 1).

KT Manual-Max: Only 2 studies performed laxity testing at maximum manual force. Although the combined data for these studies was not statistically significant, the trend showed that patients undergoing ACL replacement using PAT had 67% of the risk of laxity of ST&G patients. This risk was calculated for a KT laxity of greater than 3 mm at maximum manual force ($P = .06$). On an absolute scale, 40% of the ST&G patients and 27% of the PAT patients would have a KT laxity of greater than 3 mm at maximum manual force. This is an absolute difference of 13%.

KT 20 lbs: Three studies included KT data at 20 lbs. At 20 lbs, there was a statistically significant difference in laxity between the 2 techniques. PAT patients showed 57% of the risk that ST&G patients had for a laxity greater than 3 mm ($P = .009$). The absolute frequency is 29% for the ST&G patients and 17% for the PAT patients to have KT laxity of greater than 3 mm at 20 lbs; this is an absolute difference of 12.5%.

Lachman: Three of the 4 studies included Lachman testing. Although the relative risk estimate of 0.81 suggests that PAT is less likely to be unstable using Lachman testing, the confidence intervals were too wide to make a definitive statement. A total of 8% of the ST&G patients and 7% of the PAT patients would have Lachman scores of greater than 1 on an absolute scale. The absolute difference is 1%.

Pivot Shift: Three of the 4 studies included pivot shift testing. The relative risk estimate of 0.63 for pivot shift again suggests PAT patients are less likely to have a positive pivot shift (defined as $>$ zero). This difference was significant ($P = .05$). Of the ST&G patients, 25% have a pivot shift of greater than zero on an absolute scale. Similarly, only 16% of the PAT patients would have a pivot shift of greater than zero. The absolute difference is 9%. Only 5% of the ST&G and 2% of the PAT patients would have a pivot shift greater than 1 on an absolute scale, with a difference of 3%.

Loss of ROM Extension: We were unable to pool these study results because of significant heterogeneity among study results. (Q statistic = 7.02, with a P value of .07). The heterogeneity might be caused by several factors. The study by Aglietti et al.[12] included the use of a postoperative splint for 1 month, during which time patients were allowed to do active flexion. The other studies allowed either immediate weight bearing without bracing[16,18] or the use of a fixed-hinge knee brace with passive and active motion exercises 3 times per day out of the brace.[15] Excluding the study by Aglietti et al.,[12] the remaining studies were not heterogeneous, and there was no significant difference between PAT and ST&G, (relative risk of 1.21, 95% CI 0.68 to 2.13). It is not possible to calculate the absolute percentages again because of the significant heterogeneity between studies.

Loss of ROM Flexion: All 4 studies provided ROM information in flexion. Although the results were more homogenous for flexion, when we defined loss of ROM in flexion as any measurable loss, there was no statistically significant difference between the PAT and ST&G ($P = .31$). The absolute frequency of loss of ROM in flexion for the ST&G group is 12% and 14% for the PAT group. This is an absolute difference of 2%.

Complications and Failures: There was no statistically significant difference in the number of complications or failures between the 2 techniques (risk ratio = 1.04; $P = .89$ and pooled risk ratio = 0.63; $P = .37$, respectively). The absolute complication frequency was 12% for the ST&G group and 12% for the PAT group. The absolute difference was 0%. The absolute frequency of failures was 4% for the ST&G group and 3% in the PAT group. The absolute difference was 1%.

Table 3. *PAT Versus ST&G: Relative Risks for Each Outcome*

Positive Outcome	O'Neill et al.[13]	Aglietti et al.[12]	Marder et al.[14]	Corry et al.[21]	Pooled Risk Ratio; *P* Value	Absolute % of PAT Patients With Outcome	Absolute % of ST&G Patients With Outcome
Return to preinjury activity level	1.05 (0.92-1.20)	1.33 (0.86-2.07)	1.03 (0.73-1.46)	1.37 (1.05-1.78)	1.18 (1.04-1.34); 0.01	75	64
Adverse Outcomes							
KT Max Manual > 3 mm	0.61 (0.24-1.51)	0.70 (0.44-1.11)	—	—	0.67 (0.44-1.02); 0.06	27	40
KT 20 lbs > 3 mm	—	0.78 (0.48-1.26)	0.63 (0.11-3.55)	0.35 (0.15-0.82)	0.57 (0.37-0.87); 0.009	17	29
Lachman > 1	1.41 (0.40-4.93)	—	0.68 (0.24-1.93)	0.21 (0.01-4.25)	0.81 (0.38-1.72); 0.59	7	8
Pivot Shift > 0	—	0.78 (0.33-1.82)	0.69 (0.31-1.51)	0.48 (0.21-1.13)	0.63 (0.39-1.01); 0.05	16	25
Pivot Shift > 1	—	0.33 (0.01-7.87)	0.47 (0.13-1.75)	1.04 (0.02-51.62)	0.48 (0.15-1.51); 0.21	2	5
ROM loss extension ≥ 1°	2.38 (0.12-48.53)	15.00 (2.11-106.49)	1.38 (0.75-2.54)	0.52 (0.10-2.75)	*	—	—
ROM loss flexion ≥ 1°	1.88 (0.42-8.46)	1.00 (0.36-2.75)	1.18 (0.82-1.70)	1.04 (0.07-16.30)	1.20 (0.84-1.72); 0.31	14	12
Complications	1.18 (0.39-3.52)	3.00 (0.13-70.83)	1.10 (0.41-2.96)	0.81 (0.31-2.06)	1.04 (0.59-1.83); 0.89	12	12
Failures	0.47 (0.07-3.22)	0.33 (0.01-7.87)	0.95 (0.06-14.55)	0.78 (0.18-3.37)	0.63 (0.23-1.73); 0.37	3	4

* As explained in the results section, we were unable to pool these results because of significant heterogeneity.

DISCUSSION

A true randomized trial between 2 surgical techniques is difficult to achieve. Any study comparing surgical techniques would be affected by the bias introduced from the skill, experience, and preference of the individual surgeons. These surgical issues are in addition to the intricacies of creating a RCT in any field. Although none of the included studies are truly RCTs, by combining the data and elucidating trends we have an excellent approximation of which procedure would be better for the average surgeon. The use of M-A allowed us to overcome 2 difficulties in performing a controlled trial in surgical therapies.[23] First, we could systematically examine how characteristics of the trial designs (patient populations, treatments) affected the results. Second, when results among the comparative trials were similar, we could calculate an average estimate of relative risk, which increased our statistical precision and helped clarify the role of PAT and ST&G autografts in ACL replacement surgery. When one procedure is consistently superior to another, relatively definite conclusions might be drawn.

To the patient there are many important issues to consider when deciding between 2 surgical techniques. The most important issue will inevitably depend on the individual patient. For some, the return to preinjury level of activity will be most important, whereas for others it might be the time to return to work. Still others might wish for the least painful operation or the lowest risk of complications. Physicians must know which treatment is most likely to meet their patients' needs, not only based on their own experience, but also on the literature. A physician skilled at both techniques and knowledge of the literature can most reliably inform a patient of the differences between the 2 techniques.

Based on this analysis, elite or professional athletes who require the greatest opportunity for return to full function would likely benefit more from the PAT technique than from the ST&G technique because of the 18% greater chance of returning to previous level using the PAT graft. A surgical technique that is more likely to return the patient to preinjury level of activity would have a distinct advantage in this and other high-performance patient populations. This difference in outcomes is both statistically significant as well as clinically relevant in the athletic population. The absolute difference in frequency of 11% means that on average, 75 out of every 100 PAT patients will return to preinjury level, whereas only 64 out of every 100 ST&G patients will do the same (Table 3).

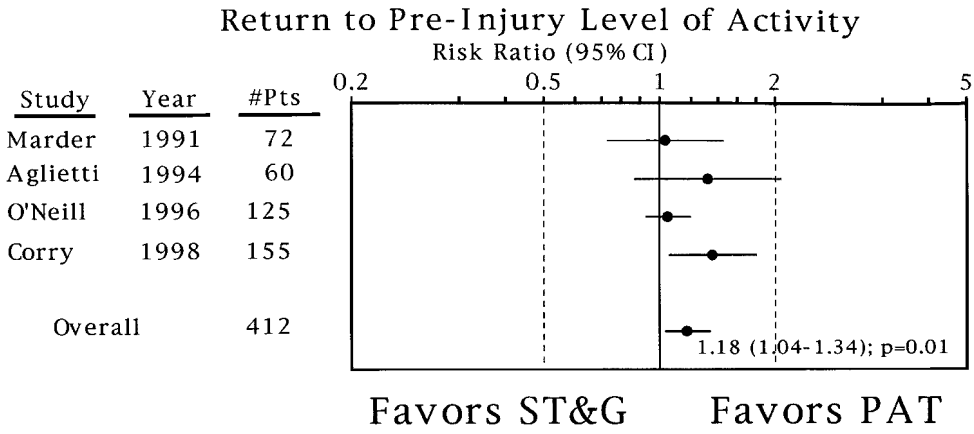

FIGURE 1. Return to preinjury level of activity. Individual study relative risks and 95% confidence intervals from the individual studies and the pooled result are shown. The outcome, return to preinjury level of activity, is statistically significant and shows that PAT patients are more likely to return to preinjury levels of activity than ST&G patients.

The 4 measures of stability assessed in this analysis were instrumented laxity at 20 lbs and instrumented laxity at maximum manual, Lachman, and pivot shift. Knee stability is greater when using the PAT graft, based on the KT arthrometer data at 20 lb. Although the difference between the 2 surgical techniques was not statistically significant at maximum manual force, the trend corroborated the evidence that PAT has greater stability than ST&G. The results of this M-A were not statistically significant for the Lachman test; however, the trends were consistent with the KT analysis, suggesting increased stability when using the PAT graft over the ST&G graft.[26,27] At 20 lbs, there is a clinically relevant lower risk of substantial laxity (greater than 3 mm) when using PAT technique. The absolute frequency of laxity, as measured by KT arthrometry at 20 lbs, shows that, on average, 29% of the ST&G patients have significant laxity whereas only 17% of the PAT patients have similar laxity. This real difference of 12% is relevant and easier to interpret than a risk ratio of 0.57.

The results of this study in regard to pivot shift are statistically significant at a level of greater than zero, but not at a level greater than one. The absolute difference in frequency of patients in the ST&G group versus PAT group was 9% at greater than zero and 2% at greater than 1. Even though the difference of 7% is significant, a pivot shift of greater than zero might not be clinically relevant or even noticeable by the patient. The absolute percentages of the frequency of pivot shift greater than 1 are only 5% for ST&G and 2% for PAT. Therefore, even if there was a statistically significant difference and it was a clinically relevant value, only 2% to 5% of the population undergoing these procedures would be affected (Table 3). Although statistical significance cannot be achieved for the other tests using the data presented in the articles included in this study, the trends presented all point toward greater stability when using the PAT graft. As with all objective assessment, consistent cut-offs must be chosen to determine clinical significance.

Inconsistency in measurements within the field of orthopedics as a whole makes objective analysis difficult. Choosing the most appropriate instruments to assess reconstructed ACLs is an active area of research.[28] Objective analysis requires a degree of standardization of technique, whether the technique is part of the procedure or part of the analysis. In this study, the inconsistency is evident when comparing the assessment of ROM. Current methods of measuring ROM have an inherent range of error, which differs depending on the instruments used. Although one study might report ROM down to 1°, another might be inaccurate below 3°. Clinically, a loss of less than 3° in ROM might not even be noticed by a patient; therefore, comparison of data within this range will not only be inaccurate, but also clinically irrelevant. This study was not able to show statistically significant differences in ROM in flexion or extension.

This study points out issues related to ROM such as preoperative and postoperative management, including early mobilization and aggressive physical therapy, which tend to minimize ROM loss, whereas immobilization tends to increase ROM loss. Currently, immobilization is not used routinely for postoperative ACL reconstruction patients.

Perhaps the most important questions regarding the choice between 2 surgical techniques are those including complication rate and failure rate. We did not find any statistically significant difference between the 2 methods in either complication or failure rate. The absolute percentage of complications and failures are similar for both techniques (Table 3). Unfortunately, specific complications relating to the individual techniques could not be compared, because the studies did not all include the same information. Two important complications that might be relevant are quadriceps weakness and anterior knee pain from the PAT harvest site and hamstring strength recovery from ST&G harvest site. The patient might be highly aware of these subjective outcomes, and they might influence the rate of recovery. Future studies should include these outcomes and include a standardized subjective assessment of how patients feel and how they would describe the outcome.

Based on the results of the included comparative trials, this M-A shows that there might be real differences between the 2 most widely used current techniques of autograft ACL reconstruction. PAT patients have nearly a 20% greater chance of returning to preinjury level of activity than do patients undergoing ST&G. Out of every 100 patients, 12 more will return to preinjury level if they receive PAT versus ST&G. In addition, PAT patients have greater knee stability. Although it appears that stability is greater in all aspects for PAT patients, this stability might be related to fixation technique or graft placement location. These issues of fixation, particularly in regard to ST&G grafts, and graft placement are currently areas of ongoing research.[29-41] One of the studies used in this M-A, Corry et al.,[21] attributed this difference in stability to gender differences among the study arms in that individual study. Other studies have investigated gender differences and found no significant difference.[42] Given that gender was not an issue addressed by this M-A, no conclusions can be made in regard to gender based on this study. It is clear, based on the included studies, that stability and return to preinjury level of activity are greater in those patients who have undergone ACL reconstruction using the PAT technique.

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