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Patellar vs Hamstring Grafts for ACL Reconstruction

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Abstract

Introduction: The anterior cruciate ligament (ACL) is one of the most common injuries in orthopedic medicine, resulting in 400,000 reconstructions every year in the United States. Bone-Patellar Tendon-Bone (BPTB) and Hamstring Tendon (HT) grafts are the most common graft types used. The objective of this review is to compare HT grafts and BPTB grafts when it comes to return to sport, returning to pre-injury level, and overall long-term functional outcomes.

Methods: A complete search was conducted using Pub Med to look for randomized controlled trials (RCTs), systematic reviews, and meta-analyses on HT vs BPTB grafts. The variables studied were return to sport, knee stability, and graft failure rates. The search was narrowed down to five articles that were chosen for clinical review.

Results: The results were mixed for the five studies reviewed. Hamstring grafts showed a small increase of graft failure rates but were correlated with less anterior knee pain compared to Patellar tendon grafts (BPTB). The BPTB grafts displayed an increased risk for osteoarthritis (OA) and anterior knee pain. The BPTB grafts also showed better knee stability compared to HT in the studies reviewed. The outcomes for returning to preinjury levels for exercise were similar for both HT and BPTB grafts.

Discussion: This review did not show a clear advantage from using one graft over the other for ACL reconstruction. The decision to use HT or BPTB needs to be determined based off of a patient's activity level and preference. The long-term complications of each graft should also be considered during the decision process. Additional research is needed to clearly define the superior graft type in regard to return to sport, reinjury, and long-term stability.

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INTRODUCTION

The Anterior cruciate ligament (ACL) is the most commonly injured ligament in the knee and is one of the most common injuries in the field of sports medicine.[1,2] Approximately 1 in 3500 people in the United States will experience an ACL injury.[1] The ACL is a fibrous band of specialized connective tissue that connects the femur to the tibia. The role of the anterior cruciate ligament is to stabilize anterior tibial translation and provide rotational stability while preventing excessive movements.[2] Unfortunately, the ACL does not have the ability to heal on its own resulting in 400,000 ACL reconstructions every year in the United States.[1] The decision to choose operative vs nonoperative treatment depends on many factors including: the patients age, comorbidities, activity level, and patient preference. For active and competitive individuals ACL reconstruction is the preferred treatment method due to a greater probability of returning to preinjury competing levels.[3]

The history of ACL repairs marks back to the late 1800s.[4] The first physician sutured the ACL to the original femoral anchor sites.[4] Six years following the procedure, the patient described being able to walk, as well as run.[4] In the 20th century, grafts replaced sutures as the repair method for ACL reconstructions.[4] The first graft used was the Fascia lata followed by the hamstring and patellar tendon grafts.[4] As medicine and surgical techniques have advanced, quadriceps tendon and allografts have become options for ACL repair. However, bone-patellar tendon-bone graft (BPTB) or hamstring tendon (HT) grafts remain the most popular.[4]

In deciding on which graft to use, it is important to take into account the advantages and disadvantages of each graft type. BPTB grafts have been associated with decreased extensor strength and anterior knee pain.[5] Risks of hamstring grafts include decreased flexor strength or

saphenous nerve injury.[5] The success of ACL reconstruction is not only determined by short-term outcomes such as return to play, but in long-term functionality when these individuals are done playing sports. The risk and probability of reinjury is also important to consider. According to the Archives of Bone and Joint Surgery, the prevalence of reinjury is between 9%-29%.[6] Although ACL repair has been around for centuries, there is no agreement on the superiority of either graft type in medical literature. The purpose of this review is to determine if hamstring grafts are superior to BPTB in terms of return to physical activity, reinjury and long-term stability.

METHODS

PubMed database was searched using the key terms “Patellar tendon graft”, “ACL reconstruction” and “Hamstring graft”. MeSH and Boolean operators were added to produce a final search of "autograft" or "graft" AND "hamstring” AND "tendon" AND "ACL" AND "reconstruction" AND "patellar". This search populated 578 results. The results were further condensed to twenty-three articles with the following filters: RCTs, systematic reviews, meta-analyses, English language, free full tex available, and published between 2019-2024. Eight articles were excluded due to including allografts and quadricep tendon autografts in their studies. Three articles were excluded based on having narrowed population in their studies. The remaining articles were reviewed and included or excluded based on the characteristics of each study with five articles being selected.

RESULTS

Study Goals: The studies included in this review had a mix of different study goals. Refer to table 1 to see a layout comparing the study goals amongst the various reviews. Bergeron et al[9] conducted a level 1 meta-analysis of randomized control trials (RCT) comparing BPTB and HT grafts. This review included 29 studies with a total of 3099 patients with a minimum of a 1

year follow up.[9] The study consisted of 1290 patients in the BPTB group and 1106 in the HT group.[9] The goal of this study was to assess return to preinjury level of play comparing both graft types, as well as assess secondary outcomes of knee stability and readiness for return to sport (RTS).[9] This review included an analysis of subgroups by age.[9] DeFazio et al conducted a level 4 systematic review of 20 articles investigating 2348 athletes who had ACL reconstruction with at least 1 year follow up.[7] Of the 2348 patients who underwent ACL reconstruction, 610 patients received BPTB autografts, and 1738 patients received HT autografts.[7] The objective of this study was to compare BPTB and HT grafts with RTS, return to preinjury level, and rerupture rates.[7] A systematic review of RCTs by Hoge et al, looked at 299 patients with a mean follow up of 15 years.[5] The primary goal of this study was to look at long-term functional and clinical outcomes.[5] Secondary objectives were to analyze radiographic evidence of osteoarthritis (OA), patient reported knee pain, and graft failure rates.[5]

Migliorini and co-authors conducted a randomized meta-analysis looking at data from 95,575 procedures comparing patient reported outcomes (PROMS), joint laxity, failure rate, anterior knee pain, and RTS.[8] A sample size of 1298 random patients were enrolled in this study with 610 in the BPTB group and 688 in the HT group.[8] A meta-analysis of RCTs was performed by Zhao et al.[10] The data collected in this review was based on patients who had a minimum follow up of 5 years to assess clinical function, knee stability, post op complications, and radiographic evidence of osteoarthritic changes.[10] The postop complications assessed in this study were anterior knee pain, kneeling pain, failure of graft, and loss of extension and flexion.[10]

Inclusion Criteria: The inclusion criteria utilized by the studies were very similar with varying differences. All 5 studies included articles that compared HT vs BPTB grafts. Hoge and colleagues were the only study that did not also analyze the impact between the number of HT

strands used.[5] Most of the studies included athletes and non-athletes for the patient demographic. In the study completed by Hoge et al the mean age of patients during surgery were 26 to 28.2 with a mean age of 41.3 to 45.5 at the time of follow up.[5] Migliorini et al had a similar age at time of surgery with a median age of patients being 27.5 years old.[8] The research completed by DeFazio et al and Zhao et al had a broad range of ages represented in their studies.[7,10] DeFazio and co-authors had a patient demographic between 14-53 years old. Zhao and colleague's included patients between 22-45 years old.[7]

A majority of the studies required research to be in the English language. Migliorini et al stated articles in English, German, Italian, French, and Spanish were eligible, and Bergeron et al allowed articles from any language to be included in their study.[8,9] Every study utilized level 1 evidence in their research and four studies included level 2-4 evidence.[5,7-10]

Exclusion Criteria: The exclusion criteria had some differences among the studies. Three studies excluded articles that were not in the English language.[5,7-10] DeFazio et al and Migliorini et al excluded any study that used a double bundled HT procedure for ACL repair.[7,8] DeFazio et al also excluded patients who were not athletes in their study.[7] Articles including allografts, quadricep tendon autografts, revised ACL reconstructions, and graft augmentation were excluded.[7] The reviews conducted by Hoge et al, Migliorini et al, and Zhao et al also specifically excluded invitro, animal, and cadaveric studies.[5,8,10] Sexually immature patients were specifically mentioned for exclusion in the studies conducted by DeFazio et al and Migliorini et al.[7,8] Bergeron et al was the only study used in this review that excluded articles that did not use level 1 evidence.[9]

Methods of Measurement: The studies in this review used various assessment tools to evaluate subjective and objective patient care outcomes. To measure stability, every study used

the Lachman test and pivot shift test except for DeFazio et al[7]. who did not measure stability in their review. Three studies included instrumental laxity testing. Bergeron and his colleagues utilized KT-1000 arthrometers whereas Migliorini and his colleagues used KT-1000 and KT-2000 arthrometers.[8,9]

Zhao et al and Hoge et al were the only studies to compare the likelihood of developing OA in their studies.[5,10] Both studies used Kellgren-Lawrence [K-L] classification and IKDC grading scale to evaluate for degenerative changes.[5,10] Questionnaires were used in every study except DeFazio et al.[7] These questionaries provided subjective data to determine reported patient care outcomes regarding pain, functionality, and overall post-surgery satisfaction. Every study utilized the Lysholm knee score and the Tegner Activity Scale questionnaires.[5,7-10] These assessments looked at the participants readiness to return to play and the level of sport competition.[10] The review by Bergeron et al used additional questionnaires; the Cincinnati knee scoring system and the ACL Quality of life score.[9]

Statistical Methods and Analysis: A combination of PubMed, Embase, Cochrane, Google scholar, Scopus, and Medline library databases were used to accumulate the data provided in these studies.[5,7-10] Revman 5.3 software was used to perform statistical analysis of outcomes produced in the studies by Zhao et al and Bergeron et al.[9,10] Migliorini and colleagues used STATA Software/MP, Version 14 for the statistical analysis in their studies.[8] The reviews conducted by Hoge et al and DeFazio et al did not report what software was used to analyze data.[5,8] Each study in this review considered a P value of <0.05 as clinically significant and used a confidence interval of 95%.[5,8]

Two studies directly discussed return to sport rates comparing BPTP and HT grafts. In the study completed by DeFazio et al, all included data was reported at a minimum of 1 year follow

up.[7] Of the 610 athletes receiving BPTP grafts, a mean rate of 81% returned to sport.[7] A mean rate of 70.6% was achieved by the HT group of 1738 athletes for RTS.[7] The study suggests that participants who received a BPTB grafts were 15% less likely to be able to return to sport 0.85, (CI 95%, 0.55-1.32).[7] This data set was deemed statistically insignificant due to the confidence interval.[7] Migliorini and colleagues compared BPTB, two strand hamstring tendon grafts (2SHT), and four strand hamstring tendon grafts (4SHT) with RTS.[8] The data demonstrated that 4SHT grafts were superior to 2SHT grafts with a mean difference MD = -1.1, (CI 95%, 1.45 - 0.74); P= < 0.0001).[8] 2SHT grafts were inferior to BPTB grafts with MD = .09, (CI 95%, -1.25 to -.054); P= <.0001.[8] When comparing 4SHT grafts with BPTB grafts, the study showed 4SHT grafts to be quicker with returning to sport MD = 0.2; (CI 95%, 0.03-0.36), P = 0.01.[8] The data in this study ultimately illustrated that using 4SHT grafts allowed for the quickest return to sport with BPTB being quicker than 2SHT.[8] The results in this study were deemed statistically significant.[8]

Comparison of BPTB vs HT grafts for return to preinjury level was discussed in three reviews; Bergurson et al looked at 13 studies with 1029 participants to evaluate for this outcome.[9] The minimum follow-up time for patients to be included in this study was one year.[9] The relative risk ratio (RR) for one study could not be determined due to every participant being able to return to preinjury level.[9] The overall RR was 1.03 (CI 95%, 0.91-1.17) and an overall P value of 0.63.[9] This data suggests that neither BPTB nor HT are superior to one another when considering all studies together.[9] The results were not affected by age when looking at the participants who were 30 years and younger.[9]

DeFazio et al's review showed 50% (209/418) of patients who had ACL reconstruction with a BPTB graft were able to return to preinjury level[7]. A total of 576 of the 1188 patients

(48.5%) with a HT graft were also able to return to preinjury level.[7] These results were evaluated by patients with at least one year follow up.[7] Even though BPTB grafts were slightly favored over HT grafts for return to preinjury level. These results were not statistically significant odds ratio 0.98 (CI 95%,0.82-1.16) to say one graft type was superior to the other.[7]

Five studies with 396 patients were reviewed in the meta-analysis completed by Zhao and colleagues for returning to preinjury level.[10] The participants in this study were evaluated with a minimum of a 5 year follow up.[10] Zhao et al had similar outcomes as in the previous studies with neither BTPB or HT grafts being better than the other OR=1.01, (CI 95%, 0.67–1.52); *P*=0.96[10]. The results were reported as not statistically significant.[10]

The evaluation for comparison of rerupture/graft failure rates were assessed by three studies in this review. DeFazio and colleagues reported that BTPB and HT grafts had similar rerupture rates with a pooled data rate of 2.2% BTPB and 2.5% HT RR 0.67 (CI 95%, 0.12-3.60)[7]. The wide CI indicates that the results are not statistically significant.[7] Graft failure was defined by Hoge et al as a ruptured graft needing reconstruction.[5] The data reported in their study also suggested no statistical significance $P < 0.05$ with an average graft failure rate of 7.75% BTPB and 9.35% HT.[5] In contrast, Zhao and colleagues favored BPTB grafts with results that were reported as statistically significant OR=0.59, (CI 95%, 0.38–0.91); *P*=.02.[10] Migliorini and colleagues expressed no conclusions could be made due to inconsistencies in data (p-value = 0.008).[8]

Manual and instrumental stability were both used as markers for functional outcome. The Lachman and Pivot test were used to evaluate manual stability and either KT-1000 arthrometer or KT-2000 arthrometer assessed instrumental stability.[5,7-10] The results for instrumental laxity were reported using side-to-side differences in mm. Bergeron et al defined a positive Lachman

test as anterior translation of more than 3mm[9] while Hoge et al reported data based on a 0-3 grading scale.[5] The pivot test looks for rotational instability during active movement[8]. In the analysis completed by Bergeron et al for the Lachman test (832 patients)[9], values did not favor one graft type over the other RR 0.80, (CI 95%, 0.56-1.14); P =0.21.[9] However, in the pivot test BPTB grafts had significantly better outcomes than HT grafts RR .66 (CI 95%, 0.50-0.86); P = .002.[9] Bergeron and colleagues did not appreciate a significant difference in side-to-side knee laxity when measuring with the KT-1000.[9] Hoge et al had similar Lachman test outcomes with both graft types having a high percentage of patients receiving Grade 0 and Grade 1 ($P<0.05$).[5] Hoge and colleagues also reported no significant difference in the pivot test or side-to-side measurements using the KT-1000.[5] Zhao et al's review showed no significant difference in graft types when assessing the Lachman test OR=0.86, (CI 95%, 0.56 -1.32), Z=0.67, P=.50[10], Pivot test OR=0.68, (CI 95%, 0.44 -1.06); P=.09 or side-to-side differences MD=−0.32, (CI 95%, -0.81 to 0.16); P=.19. The meta-analysis completed by Migliorini had similar Lachman test results as in the previous reviews when assessing all three graft types (BPTB, 2SHT, 4SHT).[8] There were no statistical differences in graft types when assessing the Pivot test or instrumental laxity.[8]

Osteoarthritis was noted in two reviews by looking at radiographic evidence of joint space narrowing and classifying the OA based off two scoring systems: Kellgren-Lawrence [K-L] classification and IKDC grading scale. In the analyze by Hoge et al, one study using the IKDC grading scale reported the BPTB group showed significant OA changes compared to the HT group.[5] In the same study 29% of HT patients had a normal grading (P = 0.04).[5] The studies who referenced the K-L classification did not see a difference between graft types. The meta-analysis by Zhao et al showed no significant differences of OA changes when comparing either

graft type OR=0.76, (CI 95%, 0.52 -1.10), Z=1.44, P=.15.[10] Zhao and colleagues also reported that there was no statistical difference in loss of flexion OR=1.09, (CI 95%, 0.47-2.54); P=.85).[10]

The Lysholm and Tegner score used for subjective data across the studies showed no statistical difference amongst the reviews completed by Hoge et al and Zhao et al.[5,10] In Migliorini et al's review the BPTB had superior scores for both Lysholm (P = 0.3) and Tegner (P=0.5) compared to 2SHT and 4SHT.[8] Bergeron and colleagues reported that HT ranked superior to BPTB in the Lysholm scoring MD =−0.79 (CI 95%, -1.78 - 0.21); P = .12 but was inferior to BPTB with Tegner scoring MD = 0.26 (CI 95%, -0.44 - 0.95); P = .47.[9] The Cincinnati score showed in favor to BPTB MD = 0.38 (CI 95%, -3.74 - 4.50); P = .86).[9]

DISCUSSION

Overall, the studies were inconclusive on which graft type is superior for ACL reconstruction. BPTB grafts demonstrate greater knee stability, but at the expense of an increased likelihood for long-term complications like OA or anterior knee pain. 4SHT had the quickest return to sport rate but carried a higher risk for graft failure. Graft type had no effect on returning to preinjury level. HT grafts have a lower risk of kneeling or anterior knee pain. Different factors such as patient preference, activity level, and age are important aspects to consider when deciding on treatment and graft type. The decision to choose between a HT and BPTB graft should be tailored to the patient's wants, needs, and expectations post-surgery.

Strengths and Limitations There were varying strengths and limitations regarding each review. DeFazio et al's review focused on the athletic population who are at a very high risk for these types of injuries[7]. The study offered a thorough investigation on returning to sport and returning to preinjury level of play[7]. One of the major limitations of this study was the quality of

the data[7]. Most of the studies used level 3 and level 4 evidence.[7] Some of the studies included were over 10 years old which increases the likelihood of studies using outdated rehabilitation protocols.[7] Using outdated protocols could influence the recovery time and skew results. Most of the data used were from past studies, which increases the risk of selection bias.[7] As stated in DeFazio et al's discussion, there was not a clear definition on what subjective outcomes were which could also skew the results.[7] The review completed by Bergeron et al used the Cochrane Handbook for Systematic Reviews of Interventions to institute the methods and to increase the precision of their study.[9] This review carried the highest quality of evidence possible due to the study being a systematic review of RCTs.[9] Some of the limitations of this study can be attributed to the search and selection process. The search strategy implemented might have left out pertinent data leading to an exclusion of studies. The numerical values were converted from median to mean in some of the data and this may have reduced accuracy.[9] Only one study in the review used 2SHT as a subgroup and this may skew some of the results as well.[9] In the Meta-analysis completed by Hoge et al, one of the greatest strengths of this study was the 10-year minimum follow-up time.[5] This lengthened follow-up time allowed the study to have a greater chance of recognizing graft failure, and long-term complications compared to shorter studies. The longer follow-up time unfortunately also poses as a limitation, due to lack of patient follow-up that can negatively affect the outcomes of the study. The radiographic results could not be connected to patient complaints of knee pain; therefore, the significance of this data could not be determined in this review.[5] Some strengths of the review completed by Zhao et al include a medium follow up time of 5 years and studies with level I and II evidence.[10] There are limitations with predicting functional knee stability using the Lachman and pivot test.[10] The tests are unable to entirely mimic the dynamic movements occurring during sports play thus limiting

the reliability of these results.[10] The varying patient population, rehab plan, and follow-up times in the study also pose as a limitation that could affect outcomes.[10] Unlike the other reviews, the review by Migliorini et al consisted of following patients in real time vs looking at older studies.[8] Another strength of this review was that 62% of the studies were randomized to minimize bias.[8] The rehab protocols used for each study in this review could not be analyzed because of the deficit in the amount of quantitative data available.[8]

Conclusion Advantages and limitations for both graft types were identified in the reviews used in this study. Despite the advantages and limitations discovered, both graft types are adequate choices for ACL reconstruction. More research is needed to determine graft superiority in terms of return to physical activity, reinjury and long-term stability.

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Table 1: Study Goals

Authors	Return to preinjury level	Readiness to return to sport	Rerupture rate/Graft failure	Knee stability	Knee pain	Radiologic evidence of osteoarthritis
Hoge et al.	X		X	X	X	X
Defazio et al.	X	X	X			
Bergeron et al.	X	X		X		
Migliorini et al.	X	X	X	X	X	
Zhao et al.	X	X	X	X		X