

## Research Article

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# No Difference in Failure Rates Between Hybrid Grafts Compared with Hamstring Autografts Following ACL Reconstruction

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### Abstract

**Background:** Hamstring tendon autografts, for ACL (anterior cruciate ligament) reconstruction, have demonstrated a higher re-rupture rates when graft diameter of <8 mm is chosen. In the event that an autograft yield a graft diameter <8 mm, augmentation with allograft creates a hybrid graft with increased diameter. Clinical outcomes of this hybrid graft have yet to be established.

**Purpose:** To assess clinical outcomes and failure rates of an adult population who undergo augmentation with allograft compared to patients with hamstring autograft alone.

**Methods:** A retrospective chart review of primary ACL reconstructions performed by 4 sports fellowship trained surgeons at a single institution between 2010-2016 identified 23 patients with hamstring autografts and allograft augmentation. A comparison group of 23 patients consisted of patients who underwent ACL reconstruction with hamstring autograft of >8 mm diameter was then selected. The comparison group was matched based on age within 3 years. Graft failure was defined as revision ACL reconstruction or evidence of graft failure on clinical exam (no end point on lachman or pivot shift) or MRI evidence of retear. International Knee Documentation Committee (IKDC), Marx Activity, and Knee injury Osteoarthritis and Outcome (KOOS) scores were obtained. Patients were contacted to obtain information regarding outcome scores, revision procedures, return to sport, and complications. A minimum follow up time was set at 12 months.

**Results:** Forty-six patients met criteria for inclusion in this study and had follow up data. The hybrid group had a total of 23 patients consisting of 7 men and 16 women with an average age of 31 years (Range 17-51 years). The autograft group had a total of 23 patients consisting of 17 men and 6 women with an average age of 33.3 years

(Range 15-48). The average follow-up between both groups was 31.5 months (range 12-63 months). The graft failure rate in the hybrid group was 8.7% (2 of 23 patients), while the autograft group demonstrated a graft failure rate of 4.3% (1 of 23 patients) ( $p=0.49$ ). In the hybrid ACL group, the mean IKDC was 67.8 (CI 59.8-75.9) compared to 73.8 (CI 66.6-80.9) in the autograft group ( $p=0.26$ ). The average KOOS scores for the hybrid group was 75.8 (CI 67.5-84.1) compared to 86.5 (CI 81.4-91.7) in the autograft group ( $p=0.03$ ).

**Conclusions:** In an adult population, allografts augmented hybrid ACL grafts showed no statistically significant difference compared to hamstring autograft in graft failure rates. The autograft ACL group demonstrated a higher KOOS score, though the IKDC was equivalent.

**Keywords:** ACL; Allograft; Autograft; Knee; Arthroscopy; Hybrid graft

## 1. Introduction

ACL injuries are common, affecting 200,000 persons in the United States each year [1]. Most of these patients elect to receive treatment with ACL reconstruction due to symptoms of instability or a desire to continue participation in activities that involve twisting and cutting motions. ACL reconstruction has been very successful; however, graft failure can still occur. Studies to improve the outcomes following ACL reconstructive surgery have focused on many aspects, such as fixation methods, graft type, and graft size. Bone patella bone has been considered the gold standard for reconstruction, but recently quadrupled hamstring tendon has been shown to be biomechanically equivalent in strength, at time zero, and can result in less donor site morbidity when compared to BTB (bone patella tendon bone) [2-4]. Several well-designed studies have confirmed that 8 mm serves as an important predictor of re-tear following ACL surgery [5]. Additionally, smaller hamstring autograft size is a predictor of poorer KOOS sport/recreation subscores 2 years after primary ACL reconstruction [6]. It is often difficult to predict whether or not a patient's hamstring tendons will be of sufficient size for ACL reconstruction. If the autograft is insufficient, options include a tripling of the semitendinosus graft or augmenting the repair by harvesting the hamstring tendon from the unaffected extremity or by adding allograft tissue.

The purpose of this study is to compare the rates of failure and patient reported outcome scores of patients undergoing ACL reconstruction with a hamstring autograft compared with an autograft-allograft hybrid ACL reconstruction. Our hypothesis is that patients with hybrid ACL graft reconstruction would have similar rates of failure and patient reported outcome scores when compared to a group of matched patients undergoing ACL hamstring autograft reconstruction.

## 2. Methods

### 2.1 Study population

This study was approved by the institutional review board for the study of human participants. A retrospective chart review was performed for patients undergoing ACL reconstruction at our institution from January 1, 2011 to

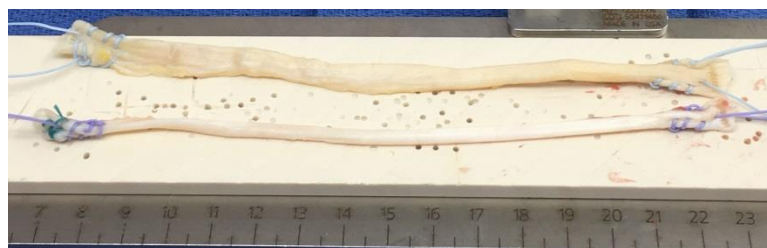
December 31, 2015. A total of 697 consecutive patients were identified. Patients were included in the study based upon the graft that was chosen for reconstruction, either those with hamstring autograft alone and those with hamstring autograft augmented with allograft. The exclusion criteria included the revision ACL setting, skeletal immaturity, and multiligamentous knee reconstruction. Application of inclusion and exclusion criteria yielded a total of 23 patients in the hybrid group with complete follow up data. Once the hybrid group was identified, matched controls were obtained from the same database. Controls were matched based on age within 3 years. All control patients underwent primary ACL reconstruction using hamstring autograft. Collected data included graft size, patient demographics, intraoperative findings, and patient reported outcome scores. Outcomes scores obtained were the International Knee Documentation Committee (IKDC), Knee injury and Osteoarthritis Outcome Score (KOOS), and Marx activity score. A minimum follow up time of 12 months was used.

## **2.2 Data collection**

A retrospective chart review was performed on all hybrid and control patients. Data was obtained from preoperative clinic notes, preoperative MRI scans, operative reports, postoperative clinic notes, and postoperative MRI scans. Patients were contacted by phone and completed IKDC, KOOS, Marx Activity surveys. They were also asked to report any additional procedures performed on their leg, return to sport, and Likert pain and satisfaction scores.

## **2.3 Surgical technique**

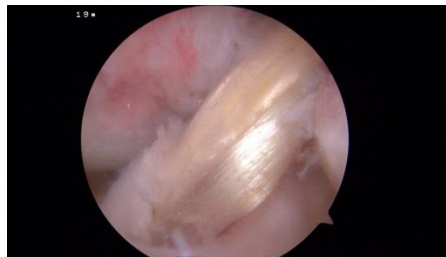
The semitendinosus and gracilis tendons were harvested via a standard anterior approach, stripped of muscle, whipstitched on both ends, and folded over to form a 4-stranded graft. This graft was then measured to determine diameter. Grafts with a diameter of less than 8 mm were augmented with a semitendinosus tendon allograft (Figure 1). An arthroscopic assisted technique was then used to complete the ACL reconstruction. Femoral tunnels were drilled through a transtibial method or the anterior medial portal per the preference of the attending surgeon. The femoral tunnel was drilled to the same diameter as the prepared graft. Femoral fixation was performed with suspensory fixation in all cases using the EndoButton (Smith and Nephew, London, England). Tibial fixation was achieved with an interference screw and backed up with either a staple, a suture to a post or a knotless suture anchor (Figure 2, 3). Unless a concomitant meniscal repair was performed, all patients underwent a standard rehabilitation protocol. At our institution, this included full weight bearing and a successive physical therapy program. Strength training was slowly begun, with open chain quadriceps activity beginning at 6 weeks. The patient is typically able to job at around 3 months with an expected return to sport and cutting activities between 6-8 months.



**Figure 1:** Clinical Image of semitendinosus allograft (top) and hamstring autograft (bottom).



**Figure 2:** AP radiograph of ACL reconstruction with hybrid graft.



**Figure 3:** Arthroscopic image of hybrid graft after ACL Reconstruction.

## **2.4 Data analysis**

SPSS for Windows (version 22; SPSS, Chicago, IL) was used for statistical analysis. An independent t-test was used for comparing continuous variables. A chi square test was used for categorical variables. The significance level was set at  $p < 0.05$ . Any patients in the hybrid group who were lost to follow up were not included in the final statistical analysis.

## **3. Results**

### **3.1 Demographics**

The hybrid group had a total of 23 patients consisting of 7 men and 16 women with an average age of 31 years (CI 26.6-35.5 years). The autograft group had a total of 23 patients consisting of 17 men and 6 women with an average age of 33.3 years (CI 29.9-36.7). Average BMI in the autograft group was 26.1 compared to 30.5 in the hybrid group ( $p=0.064$ ). The mean overall graft size was 9.1 mm (range 8-11 mm) in the autograft group and 10 mm (range 9-11mm) in the hybrid group. The average follow-up between both groups was 31.5 months (range 12-63 months), with 36 months (30.8-42.2) and 26 months (22.7-30.1) for autograft and hybrid groups respectively ( $p=0.0038$ ). In terms of concomitant procedures performed during the ACL reconstruction, 52.1% (12 of 23 patients) underwent the medial meniscus procedure in the autograft group compared to 39.1% (9 of 23 patients) in the hybrid group ( $p=0.37453$ ). Eleven patients in the autograft group (47.8%) underwent a lateral meniscus procedure compared to 5 in the hybrid group (21.7%) ( $p=0.063$ ). Additionally, 21.7% (5 of 23 patients) underwent treatment for cartilage injury in the autograft group compared to 17.4% (4 of 23 patients) in the hybrid group. In each group this treatment was limited to either microfracture or chondroplasty. The data is summarized in Table 1.

| <b>Data</b>                        | <b>Autograft</b> | <b>Hybrid</b>     | <b>p</b> |
|------------------------------------|------------------|-------------------|----------|
| Female                             | 6                | 16                | *0.0031  |
| Age (years, mean, CI)              | 33.3 (29.9-36.7) | 31 (26.6-35.5)    | 0.41     |
| BMI (kg/m <sup>2</sup> , mean, CI) | 26.1 (23.7-28.4) | 30.5 (26.4-34.6)  | 0.064    |
| Graft Diameter (mm)                | 9.13 (8.81-9.45) | 10.1 ( 9.77-10.4) | *0.00006 |
| Followup Time (months, mean, CI)   | 36.5 (30.8-42.2) | 26.4 (22.7-30.1)  | *0.0038  |
| Return to Sport                    | 20 (87%)         | 15 (65.2%)        | 0.083    |
| Associated Procedure               |                  |                   |          |
| Medial meniscus                    | 12 (52.1%)       | 9 (39.1%)         | 0.37     |
| Lateral meniscus                   | 11 (47.8%)       | 5 (21.7%)         | 0.063    |
| Cartilage Procedure                | 5 (21.7%)        | 4 (17.4%)         | 0.71     |

**Table 1:** Summary of demographic data for the study population.

| <b>Data</b>      | <b>Autograft</b>              | <b>Hybrid</b>                 | <b>p</b> |
|------------------|-------------------------------|-------------------------------|----------|
| Failure Rate     | 1 (4.3%)                      | 2 (8.7%)                      | 0.49     |
| Reoperation Rate | 4 (17.4%)                     | 3 (13.0%)                     | 0.68     |
| IKDC             | 73.8 (66.6-80.9)              | 67.8 (59.8-75.9)              | 0.26     |
| KOOS             | 86.5 (81.4-91.7) <sup>a</sup> | 75.8 (67.5-84.1)              | *0.03    |
| Pain             | 89.5 (82.6-96.4) <sup>b</sup> | 81.4 (73.6-89.3) <sup>c</sup> | 0.08     |
| Symptoms         | 82.4 (74.7-90.0) <sup>b</sup> | 79.3 (71.9-86.6) <sup>c</sup> | 0.32     |
| Activity         | 93.4 (88.5-98.4) <sup>b</sup> | 88.8 (80.5-97.2) <sup>c</sup> | 0.32     |
| Sports           | 75.3 (63.1-87.4) <sup>b</sup> | 69 (55.5-82.5) <sup>c</sup>   | 0.44     |
| Quality of Life  | 68.7 (55.7-81.7) <sup>b</sup> | 57.8 (44.9-70.7) <sup>c</sup> | 0.27     |
| Return to Sport  | 20 (87%)                      | 15 (65.2%)                    | 0.083    |
| Marx             | 7.8 (5.63-9.94)               | 5.9 (4.00-7.8)                | 0.18     |

**Table 2:** Summary of results for the study population. All are n=23 unless noted. 95% CI in parenthesis a: n=21; b: n=19; c: n=20.

### 3.2 Failure rate

The graft failure rate in the hybrid group was 8.7% (2 of 23 patients), while the autograft group demonstrated a graft failure rate of 4.3% (1 of 23 patients) (p=0.49). For both groups, graft failure was determined by physical examination with a pivot shift in 1 patient and arthroscopically confirmed during revision surgery in 2 patients. One patient from each group underwent revision ACL reconstruction after failure of their initial procedure. One patient with a failed hybrid reconstruction elected not to undergo revision surgery (Figure 4).



**Figure 4:** MRI of a failed hybrid ACL reconstruction.

### 3.3 Reoperation rate

In the autograft ACL group there were a total of 4 patients who underwent another procedure on their reconstructed knee after their index reconstruction procedure. One underwent a revision ACL reconstruction, another for a manipulation under anesthesia due to stiffness, a third patient underwent a partial meniscectomy on a meniscus that was repaired during their primary ligament reconstruction, and a final patient underwent irrigation and debridement of a suture abscess four weeks post-operatively from their ACL reconstruction. The hybrid group had 3 patients undergo surgery on their operative extremity after their index ACL reconstruction. One was for a revision ACL reconstruction and 2 for irrigation and debridement for surgical site infection 6 months post-operatively. The overall rates of reoperation for any reason were 17.4% (4 of 23) of the autograft group and 13.0% of those in the hybrid group [(3 of 23) (p=0.068)].

### 3.4 Functional outcomes

In the hybrid ACL group, the mean IKDC was 67.8 (CI 59.8-75.9) compared to 73.8 (CI 66.6-80.9) in the autograft group (p=0.26). The average KOOS scores for the hybrid group was 75.8 (CI 67.5-84.1) compared to 86.5 (CI 81.4-91.7) in the autograft group (p=0.03). KOOS subsection scores were available for 20 in the hybrid group and 19 in the autograft group. The subsections of the KOOS score displayed an average of 89.5 compared to 81.4 (p=0.08) for “pain”, 82.4 vs 79.27 (p=0.55) for “symptoms”, 93.44 vs 88.84 (p=0.32) for “activity”, 75.3 vs 69.0 (p=0.44) for “sports”, and 68.7 vs 57.8 (p=0.27) for “quality of life” in the autograft and hybrid groups, respectively. In terms of return to sport, 65% (15 of 23 patients) in the hybrid group and 87% (20 of 23 patients) in the autograft group returned to their sport (p=0.08). Lastly, the Marx activity score of patients in the autograft group was 7.8 opposed to 5.9 in the hybrid group (p=0.18). Outcome scores are summarized in Table 2.

## 4. Discussion

In our series, allograft-autograft hybrid hamstring graft failure had no statistically significant difference compared to that of the hamstring autograft group. Failure rate of the hybrid graft was 8.7% (2 of 23 patients) compared to 4.3% (1 of 23 patients) in the autograft group (p=0.49). Our study did not demonstrate a statistically significant difference

in the IKDC patient reported outcome score, but it did show a difference in the overall KOOS score [86.5 (CI 81.4-91.7) in the autograft group, 75.8 (CI 67.5-84.1) In the hybrid group (p=0.03)]. Despite this difference, there was no statistically significant difference in the subsections of the KOOS between the two groups; in each subsection the scores were lower in the hybrid group compared to the autograft group. Hybrid grafts have been a commonly used solution for a patient with a small hamstring autograft diameter. It allows the surgeon to augment the overall graft size to create an overall graft diameter of 8mm or greater [5-7]. It has been hypothesized that supplementation of the undersized autograft with allograft could diminish the risk of rerupture associated with critically small graft diameters.

There have been several studies in recent years examining failure rates of hybrid graft constructs compared to autograft only constructs in an adult population with somewhat varied results. Burrus et al. [8] published on their series in 2015, which demonstrated a statistically significant increased rate of graft rupture or graft compromise in hybrid graft patients as compared to a control group of autograft patients. In their series, they showed a rate of hybrid graft rupture or graft compromise in 38% of knees compared to 7% of their control autograft group (p=0.005) [8]. Additionally, they showed a significantly worse IKDC score in the hybrid compared to the autograft group, 71.3 and 85.7 respectively (p=0.012). In contrast to these results, Darnley et al. published data on autograft ACL reconstructions compared to hybrid graft reconstructions using MOON registry data in 2016 [9]. In their study, they demonstrated no statistically significant difference with regards to patient outcome scores or revision surgery. In their series, revision surgery was performed in 18.5% of hybrid patients and 7.4% of autograft reconstruction patients (p=0.26). Both of these studies were underpowered to detect a difference in failure risk between hybrid and autograft, but they both showed higher rates of failure in the hybrid graft. The results from our study are in agreement with the MOON study demonstrating no difference of failure rate between the two groups, but similar to the study by Burrus et al. [8] in that we showed a statistically significantly worse patient reported outcome score. Their study demonstrated a lower IKDC score in the hybrid group, whereas our study has demonstrated a lower KOOS score. It is unclear the exact cause of our lower KOOS score. We theorize that it may be due to an overall higher level of athlete in our autograft population, compared to our hybrid population, which is in turn a direct result of the selection bias that is associated with the retrospective nature of the study. In our autograft cohort, we had 11 patients who participated in a sport at a competitive level, whereas only 6 were marked that they participated in competitive athletics in the hybrid group. Although this difference did not reach statistical significance in our study, it may contribute the disparity in KOOS scores. It is possible that a higher quality athlete may be more likely to inherently have a more robust tissue compared to an equally active, but less athletic counterpart based upon previously reported studies regarding demographics and hamstring diameter [10].

Despite the larger number of competitive athletes in the autograft group, there was an equal number of patients participating in high risk sports for ACL injury. We defined high risk sports as football, soccer, rugby, basketball, skiing. In each group there were 5 patients participating in these higher risk sports. The most common sports response for sports participation and level was recreational running between the two groups. Our study population differed with regard to proportion of females and follow-up time. The autograft group had a significantly longer

follow-up time (36.5 months vs 26.4 months,  $p=0.0038$ ), which would potentially capture more graft failures. As such, it is possible that our study underestimates the graft failures in the hybrid group. Several animal studies and human MRI studies have shown slow revascularization and ligamentization in allografts tissue [11, 12]. As a result, it has been proposed that return to activity and sport should be slower in a hybrid graft construct compared to a purely autograft reconstruction. The mean time to hybrid graft revision was 11.3 months in the Darnley et al. series. In the series reported by Burrus and colleagues all hybrid failures occurred within 9.3 months. Failures that we have reported in our study all occurred within 13 months. Allograft processing has also been shown to have an impact on mechanical properties and consideration should be given to allograft processing methods [11, 13]. In our series, which involved all sports fellowship trained surgeons, no high dose terminal irradiation was used similar to the studies by Burrus, et al. [8] and Darnley, et al. [9]. The use of low dose irradiation techniques in allograft processing has been shown to have a minimal effect on the graft's mechanical properties [14].

This study has several limitations. Similar to the other reported studies on this subject, it is underpowered to definitively determine whether there is a statistically significant difference in failure between hybrid and autograft ACL reconstructions. Additionally, the retrospective nature of the study introduces selection bias. Based on our database search, this is not a common procedure, which makes obtaining large numbers difficult. Recent studies are also demonstrating methods to predict graft size to obviate the potential need for allograft augmentation.

## **5. Conclusion**

Patients who undergo ACL reconstruction with hybrid hamstring grafts did not have a statistically significant difference in failure rate or reoperation rate compared to an autograft control group.

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