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Hamstring Autograft for Foot and Ankle Applications

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Abstract

Background: Hamstring tendon autografts may be used for foot and ankle surgeries, although reports on their effectiveness and morbidity in the foot and ankle literature are limited. We studied a cohort of patients who underwent hamstring harvest for foot and ankle applications, hypothesizing that morbidity to the knee would be limited.
Methods: We studied a cohort of patients who underwent hamstring autograft for foot or ankle applications by a fellowship-trained sports and foot and ankle surgeon since 2011. Thirty-seven patients underwent isokinetic strength testing using a dynamometer an average of 38 months postoperatively. The average patient age was 45 ± 16 (range, 18-78) years, and 54% were women. Peak flexion and extension torque as well as flexion and extension torque at 30, 70, and 90 degrees of flexion were collected at 2 different testing speeds, 180 and 300 degrees/s. t tests were used for all comparisons.
Results: At follow-up, 32 patients (86%) reported no pain at the harvest site; the remaining 5 patients reported mild to moderate symptoms. No patients were dissatisfied, and all would recommend the surgery to someone else. Flexion strength at higher degrees of flexion was significantly lower compared with extension strength as well as compared with flexion strength at lower degrees of flexion, when testing was performed at lower speed ($P < 0.05$).
Conclusions: When used for foot and ankle surgery, hamstring autografts resulted in high patient satisfaction with minimal donor site morbidity. While knee flexion strength was decreased at higher degrees of flexion, this finding did not appear to be clinically significant.
Level of Evidence: Level IV, case series.

Keywords: hamstring autograft, foot and ankle, tendon reconstruction, ligament reconstruction

Introduction

Hamstring tendon autografts (gracilis and/or semitendinosus) may be used as an alternative to allograft or local tendon grafts in foot and ankle surgery, primarily for tendon or ligament repairs in which direct repair has failed or is not possible. Hamstring tendon harvest has been abundantly studied in the setting of anterior cruciate ligament reconstruction in the knee. While both the semitendinosus and gracilis tendons have been shown to regenerate in most patients after harvest,[7,29] multiple authors in the sports literature have shown decreased hamstring strength in higher degrees of knee flexion at latest follow-up.[17,22] This deficit, with strength reported between 76% and 96% that of the nonoperated leg,[1-3,7,11,21,30] is likely to affect only high-level athletes in certain sports. Aside from findings of decreased strength, no functional consequences have been demonstrated.

Few authors have investigated the effects of hamstring tendon harvest for foot and ankle applications. Only 1 author performed dynamometer strength testing, on 26 patients who underwent semitendinosus harvest for lateral ankle ligament reconstruction.[24] In this small series, no significant difference in strength between the operated and nonoperated legs was identified. We aimed to study a larger cohort of patients who underwent harvest of the gracilis tendon, semitendinosus tendon, or both for a variety of foot and ankle applications, hypothesizing that donor site morbidity would be limited and patient-reported outcomes would be good.

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Methods

Institutional review board approval for this study was obtained from the authors' institution. All patients provided written informed consent at the time of enrollment.

Data Collection

All patients who underwent hamstring harvest for foot or ankle applications by a single fellowship-trained sports and foot and ankle surgeon (M.C.D.) since 2011 were screened for inclusion. Patients were eligible for this study if they were older than 18 years, had no history of knee pathology, and were at least 1 year from surgery. Ninety-four patients were identified. Nineteen patients were excluded for a history of knee surgery, 3 for other lower extremity (hip or knee) pathology, 1 for a diagnosis of Charcot neuropathy, and 1 for a diagnosis of muscular dystrophy. For the remaining 70 patients, clinical records were used to identify diagnosis, procedure performed, hamstring tendon(s) harvested, graft diameter and length, and any postoperative complications or additional surgeries.

Of these 70 patients, 7 (10%) refused to participate, 17 (24%) were unable to return for testing, and 9 (13%) could not be contacted. The remaining 37 patients (53%) had an average age of 45 ± 16 years (range, 18-78) and returned for isokinetic testing an average of 38 ± 12 months (range, 13-51) after surgery. Twenty (54%) were women.

At the time of enrollment, patients were asked if they had any symptoms at the site of hamstring tendon harvest, if they had had any additional surgeries since the index surgery, and if they would recommend the surgery to someone else. They were also asked, "Are you satisfied with the result of your surgery?" with 5 response options ranging from "very satisfied" to "very dissatisfied."

Indications and Operative Technique

Hamstring harvest is ideally performed in the supine position, but it can also be performed with the patient prone by flexing the knee. Given the proximal incision, spinal anesthesia was preferred over popliteal blocks. An anteromedial oblique incision was made centered over the pes anserinus. An oblique incision was in line with the infrapatellar branch of the saphenous nerve and so theoretically carried less risk for injury to this nerve than a longitudinal incision. The sartorial fascia was identified and incised at the superior edge of the pes in line with the tendon fibers. The fascia was elevated, exposing the semitendinosus and gracilis tendons, which were between the sartorial fascia (layer 1) and the superficial medial collateral ligament (layer 1).

The tendons were isolated using a Penrose drain passed around each tendon to apply traction. Any distal adhesions were released—including the medial gastrocnemius fascia, which was often adherent to semitendinosus—and the tendons were bluntly dissected as far proximally as possible. The tendons were then harvested with a tendon stripper, aiming toward the ischial tuberosity. Distally, they were released sharply off their insertion site. The sartorial fascia was reapproximated prior to skin closure.

The muscle was removed and the tendon was tubularized, typically with nonabsorbable sutures. The tendon was doubled over to increase its diameter for certain applications. The decision to take 1 or 2 tendons was dependent on the specific operation, the size of the defect, and the size of the native tendon that was being reconstructed. In the senior author's experience, hamstring tendon harvest added approximately 10 to 15 minutes to the procedure, including closure.

Isokinetic Strength Testing

Isokinetic testing of knee flexion and extension strength was performed using a Biodex System 4 Pro dynamometer (Biodex Medical Systems, Shirley, NY). One of 2 physical therapists conducted the testing using a standardized protocol. The protocol consisted of a 5-minute warm up on a stationary bicycle, followed by isokinetic testing. The right or left leg was chosen to start based on a coin flip, with the therapists blinded to the site of surgery. Each leg was tested at 2 speeds, with 5 repetitions at 180 degrees/s and 15 repetitions at 300 degrees/s, with a 30-second break between the 2 speeds. Prior to each test, each patient had 5 trial repetitions to become accustomed to the machine. Peak flexion and extension torque, as well as flexion and extension torque at 30, 70, and 90 degrees of flexion, were recorded at each of the 2 testing speeds.

Statistical Analysis

In the initial analysis, flexion and extension torque were compared between the operated and nonoperated legs using 2-tailed paired t tests. Secondarily, relative flexion and extension torque were calculated for each patient. *Relative torque* refers to the operated side's torque as a percentage of the nonoperated side's torque. Relative flexion torque (which may be affected by hamstring harvest) was compared with relative extension torque (which should be unaffected by surgery) using 2-tailed paired t tests. Differences between relative flexion torque at different degrees of flexion were also calculated with paired t tests.

Subgroup analyses included comparisons between patients who had gracilis only harvested and those who had semitendinosus only harvested, and between patients who had gracilis only harvested and those who had both tendons harvested. These comparisons were done using 2-tailed unpaired t tests.

Table 1. Procedures Performed Listed in Reference to the Tendon Harvested.

	Gracilis (n = 36)	Semitendinosus (n = 15)	Both (n = 19)
Lateral ligament reconstruction (n = 25)	11	10	4
Achilles reconstruction (n = 19)	7		12
Peroneus brevis reconstruction (n = 12)	11	1	
Tibialis anterior reconstruction (n = 12)	6	4	2
Deltoid and spring ligament reconstruction (n = 1)			1
Tibialis posterior tendon reconstruction (n = 1)	1		

Table 2. Results of Isokinetic Testing at 2 Different Speeds.[a]

		180 degrees/s			300 degrees/s		
		Operated	Nonoperated	*P* Value	Operated	Nonoperated	*P* Value
Flexion torque, ft-lbs	Peak (mean ± SD)	36.2 ± 12.8	38.8 ± 13.7	.004*	29.3 ± 11.4	31.8 ± 11.6	.009*
	30 degrees (mean ± SD)	31.2 ± 13.2	32.0 ± 14.8	.671	17.2 ± 10.6	20.2 ± 12.0	.037
	70 degrees (mean ± SD)	30.2 ± 11.4	33.5 ± 12.5	.002*	23.1 ± 9.3	25.6 ± 10.1	.013*
	90 degrees (mean ± SD)	19.7 ± 9.9	23.2 ± 11.1	.018*	9.9 ± 6.8	12.7 ± 8.2	.017*
Extension torque, ft-lbs	Peak (mean ± SD)	77.7 ± 30.1	81.1 ± 30.7	.114	57.5 ± 22.2	56.5 ± 21.5	.726
	30 degrees (mean ± SD)	42.9 ± 20.8	43.4 ± 21.9	.888	23.2 ± 12.6	23.8 ± 14.8	.750
	70 degrees (mean ± SD)	74.6 ± 29.8	78.4 ± 29.6	.075	59.3 ± 23.2	61.8 ± 26.3	.181
	90 degrees (mean ± SD)	58.8 ± 25.3	63.1 ± 26.3	.093	38.0 ± 21.1	39.2 ± 21.4	.614

[a]Peak torque values represent the peak torque produced in that testing cycle; torque was also collected during flexion and extension at 30, 70, and 90 degrees of knee flexion. *P* values reflect comparisons between the torque produced by the operated and nonoperated legs. *$P < 0.05$.

A post hoc power analysis revealed that a sample size of 30 patients would yield greater than 80% power to detect a 10-percentage-point deficit in relative flexion torque compared with relative extension torque, assuming a standard deviation of 20 percentage points.

Results

The tendons harvested and procedures performed are listed for the original group of 70 patients in Table 1. Of the 44 cases in which graft diameter was recorded, the average diameter was 4.8 mm (range, 3.5-8). Graft length was recorded for only 15 patients and averaged 26 cm (range, 22-29 cm). Two patients (3%) had a mild postoperative complication at the tendon harvest site: 1 developed a mild cellulitis that resolved with oral antibiotics, and the other developed a small hematoma at the site, which resolved spontaneously. There were no additional surgeries related to the hamstring harvest.

Of the 37 patients who were interviewed and returned for strength testing, 25 (68%) were very satisfied with their operative result and 10 (27%) were satisfied; 2 patients were neither satisfied nor dissatisfied, and no patients were dissatisfied. All patients would recommend the surgery to someone else. Three patients noted some numbness at the harvest site. Thirty-two patients (86%) reported no pain at the harvest site; 3 cited mild, rare pain; and 2 cited moderate pain in the leg but with other potentially confounding factors, including lumbar radiculopathy.

Peak flexion torque as well as flexion torque at 70 and 90 degrees of flexion were significantly lower on the operated side compared with the nonoperated side ($P < 0.05$; Table 2). Relative flexion strength (strength as a percentage of the nonoperated side) at higher degrees of flexion was significantly lower compared with relative extension strength when testing was performed at a lower speed (Table 3). Relative flexion strength at 90 degrees was lower than relative flexion strength at 30 degrees ($P = 0.013$) as well as at 70 degrees ($P = 0.040$), and relative flexion strength at 70 degrees was greater than that at 30 degrees ($P < 0.05$).

When patients who had gracilis harvested were compared with those who had semitendinosus harvested, there were no significant differences in relative flexion torque (Table 4). When patients who had gracilis harvested were compared with those who had both tendons harvested, relative flexion torque in high flexion was significantly lower in those who had both tendons harvested (Table 4).

Discussion

In this study, we report on the largest cohort of patients in the literature who underwent hamstring tendon harvest for foot and ankle applications. Among this cohort, satisfaction was high and harvest site pain was rare. While we found

Table 3. Relative Flexion and Extension Torque at 2 Different Speeds.[a]

Torque, % of Nonoperated Leg	180 degrees/s			300 degrees/s		
	Flexion	Extension	*P* Value	Flexion	Extension	*P* Value
Peak, %, ± SD	95.5 ± 14.5	94.7 ± 11.7	.756	95.1 ± 18.8	97.6 ± 15.0	.388
30 degrees, %, ± SD	107.0 ± 49.2	103.2 ± 40.2	.587	88.5 ± 39.0	97.0 ± 42.6	.280
70 degrees, %, ± SD	90.3 ± 15.0	94.5 ± 11.0	.143	92.4 ± 22.8	97.9 ± 15.8	.206
90 degrees, %, ± SD	83.0 ± 25.8	93.9 ± 15.1	.029*	96.6 ± 70.2	94.2 ± 27.0	.834

Flexion and extension torque values are reported as percentages of the values reported for the nonoperated leg. *P* values compare relative flexion and extension strength. *$P < 0.05$.

Table 4. Results of Pairwise Comparisons.[a]

Testing Speed		Gracilis (n = 22)	Semitendinosus (n = 6)	*P* Value	Both Tendons (n = 9)	*P* Value
180 degrees/s	Peak torque	98.8 ± 14.9	90.5 ± 11.8	.219	90.5 ± 14.1	.163
	Torque @30	117.3 ± 59.4	82.7 ± 25.5	.208	95.0 ± 20.1	.267
	Torque @70	92.9 ± 16.0	89.2 ± 12.6	.610	85.0 ± 14.0	.211
	Torque @90	87.9 ± 18.3	90.0 ± 30.0	.829	65.4 ± 33.5	.030*
300 degrees/s	Peak torque	97.6 ± 17.2	93.4 ± 22.9	.624	89.9 ± 20.9	.293
	Torque @30	94.5 ± 44.2	84.4 ± 30.6	.668	78.8 ± 27.7	.396
	Torque @70	96.2 ± 26.7	93.9 ± 19.7	.848	82.2 ± 8.1	.137
	Torque @90	107.3 ± 74.9	118.0 ± 75.0	.760	50.9 ± 25.5	.048*

[a]Pairwise comparisons of relative flexion torque between patients who had gracilis harvested, those who had semitendinosus harvested, and those who had both tendons harvested are shown. Torque values are reported as percentages of the values reported for the nonoperated leg. *P* values reflect the pairwise comparisons with patients who had gracilis alone harvested. *$P < 0.05$.

statistically significant deficits in knee flexion strength at higher degrees of flexion relative to the nonoperated leg, these findings did not appear to be clinically significant.

Multiple prior authors have investigated the effect of hamstring tendon harvest on knee flexion strength, although primarily in the setting of anterior cruciate ligament (ACL) reconstruction. The predominant finding has been of decreased knee flexion strength in higher degrees of flexion.[17,22] The largest study compared 113 patients who received gracilis and semitendinosus tendon autograft to 175 patients who received bone-patellar tendon-bone autograft (BPTB). In this study with a mean 5-year follow-up, hamstring isokinetic peak torque was only 2% higher in the BPTB group. Among those who underwent hamstring harvest, mean peak knee flexion strength was at least 95% of the nonoperated side. In addition, there was no difference between the groups in functional outcomes.[18]

Yasuda et al[37] attempted to isolate the effect of hamstring tendon harvest by randomizing 65 patients undergoing ACL reconstruction to undergo hamstring harvest from the injured or noninjured side. In both groups, quadriceps strength increased on the noninjured side as expected, given the necessity of decreased weight bearing on the injured side. In patients with hamstring harvest from the noninjured side, the noninjured leg experienced an acute decrease in isometric hamstring strength of 72% at 1 month, which recovered to 105% by 3 months. By 12 months, hamstring strength was comparable with preoperative strength but decreased compared with the patients who did not have any surgery on the noninjured leg.[37]

In the foot and ankle literature, good outcomes have been reported from use of both hamstring allograft and autograft for tendon and ligament reconstructions. Most of these studies have focused on lateral ankle ligament reconstruction* and Achilles tendon reconstruction.[8-10,19,25,33] One case report described use of a gracilis autograft for tibialis anterior tendon reconstruction.[36]

The largest cohort of patients in the literature was reported by Xu et al,[35] who compared patients who received either semitendinosus autograft (n = 32) or allograft (n = 36) for lateral ankle ligament reconstruction. The autograft group experienced fewer febrile days postoperatively as well as a faster time to healing. Four patients in the allograft group were treated for postoperative incisional swelling. There were no differences in clinical or radiographic outcomes between the 2 groups. No patients reported pain or weakness related to the harvest site, and no patients required reoperation. This study highlighted the potential drawbacks

*References 4, 6, 13, 15, 16, 20, 24, 26, 28, 34, 35.

of using allograft in a subcutaneous area, where immune reactions to the allograft may impair or delay healing.[35]

Only one study, by Paterson et al,[24] assessed postoperative hamstring strength using dynamometer testing. Twenty-six ankles underwent lateral ankle ligament reconstruction using semitendinosus autograft. There was no significant difference between average eccentric or concentric knee flexion strength of the operated and nonoperated legs. However, the authors did find slightly greater strength on the operated side near full extension.[24] This finding was also identified in our study: that flexion strength was decreased at higher degrees of knee flexion. We found a difference between flexion strength of the operated and nonoperated legs only when the knee was at higher degrees of flexion (70 and 90 degrees).

Unlike Paterson et al, we also found that peak flexion torque was reduced relative to the nonoperated leg. However, there was no difference when relative flexion torque values were compared with relative extension torque values. This latter finding suggests that in some patients, overall deconditioning in the operative leg may have a role in explaining lower torque values on that side, since deconditioning would lead to decreased flexion as well as extension strength on the operated side.

Data on the diameter and length of the hamstring autografts in this study were limited. However, the graft lengths we reported are consistent with reports in the ACL literature, which cite means in the range of 28 to 29 cm, with shorter lengths associated with shorter height.[14] Regarding diameter, both tendons doubled yields a graft diameter greater than 7 mm in more than 90% of Caucasian patients,[14] with smaller diameters reported in an Asian population.[23] Generally, patients with lower height, weight, and body mass index (BMI) and older female patients are likely to have smaller graft diameters.[32]

Among the benefits of hamstring autograft is its cost. The relative cost of autograft versus allograft has not been studied in the setting of foot and ankle surgery, but it has been studied in the setting of ACL reconstruction. Cooper and Kaeding[5] compared ACL reconstruction with hamstring autograft versus tibialis anterior allograft. They found that the mean total hospital cost was more than $1100 greater for patients who received allograft, a difference largely attributable to the cost of the allograft. There was no statistically significant difference in the costs related to the operating room or anesthesia.[5] Multiple other authors have also identified a cost benefit to hamstring autograft relative to allograft for ACL reconstruction, despite longer operating times associated with autograft harvest.[12,27,31] As providers are increasingly held accountable for the costs of treatment, use of autograft should be considered in appropriate cases.

Advantages of our study include its relatively large sample size compared with previous studies and diversity of procedures performed. There are several weaknesses of our study. First, preoperative isokinetic testing was not performed, preventing us from comparing preoperative to postoperative strength. As a substitute, we compared the operated leg to the nonoperated leg, a strategy also used by previous authors.[24] Second, a large number of the eligible patients identified were unable to return for isokinetic testing, potentially introducing selection bias. Third, relatively few patients underwent semitendinosus harvest, limiting our ability to compare the effect of semitendinosus harvest to gracilis or both tendon harvest.

In conclusion, this study showed that hamstring autografts could be used for various reconstructive procedures in the foot and ankle with high patient satisfaction and minimal donor site morbidity. A large amount of tissue could be obtained, with graft diameters up to 7 mm and lengths up to 28 cm, to allow for the filling of large defects. Hamstring autografts represent an attractive alternative to allograft and local harvest options: allografts are expensive and carry the potential for infection and immunogenicity, while local grafts such as the flexor hallucis longus tendon may provide insufficient tissue and result in local morbidity. The deficits in knee flexion strength following hamstring tendon harvest, seen primarily in higher degrees of knee flexion, are unlikely to affect function. This notion is supported by the high patient satisfaction and rarity of complaints about the knee among patients in this study. If there are concerns about decreased knee strength at high degrees of knee flexion, 1 tendon may be harvested instead of 2, as this seems to have less morbidity than harvesting both tendons.

Declaration of Conflicting Interests

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