



E-ISSN: 2395-1958
P-ISSN: 2706-6630
IJOS 2020; 6(2): 904-909
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www.orthopaper.com
Received: 05-01-2020
Accepted: 06-02-2020

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Recovery of knee function associated with regeneration of semitendinosus and gracillis grafts used for reconstructive procedures

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DOI: <https://doi.org/10.22271/ortho.2020.v6.i2o.2158>

Abstract

Background: The semitendinosus and gracillis have been a significant source of graft material for reconstruction. Numerous studies have shown that harvesting the semitendinosus and gracillis reduce knee flexion, especially deep flexion angles of the knee. Following graft harvest the hamstring tendons regenerate within 24 months but the degree of recovery and redevelopment of semitendinosus varies from individual to individual. The study was aimed at demonstrating recovery of function signifying regeneration potential in the hamstring tendon namely the semitendinosus and gracillis used as graft material for reconstruction procedures

Materials and methods: The retrospective study was done at Lourdes Hospital, Ernakulam, Kerala. Patients who presented with tears were grouped based on the tendon used for reconstruction into ST group in whom the semitendinosus alone was used for reconstruction and STG group in whom the semitendinosus and gracillis was used for reconstruction. Only Patients with ACL tears was considered in this study as the procedure to access recovery of knee function could be standardised across all patients included in the study. To compensate for the recovery of range of movements associated with acute ACL rupture patients was further grouped based on time of injury to reconstruction. GROUP I included patients who underwent ACL Reconstruction within 4 months of injury, GROUP II within 4-8 months of injury and GROUP III within 8-12 Months of injury.

The range of motion of the knee was evaluated in the outpatient department when the patients came for review. Measurement was done with the patient supine on an examination bed using a goniometer. The interlimb difference was recorded. Patients were followed up after reconstruction and range of movements assessed at 3 months, 6 months and one year

Results: The range of movements in Group I Improved steadily with time in all patients who were Operated with semitendinosus (ST) and semitendinosus and gracillis (STG) grafts. Pt operated with ST alone showed significant improvement, but there was no difference at 6th Month or 1 year time (other P Values>0.05).In comparison with opposite limb Patients attained more than 90% Rom in ST group compared to STG. Statistically minor significant difference between relative Range of Movement was found at 3 months and 6 months of follow up in Group I, II and III but at 1-year period there was no significant difference in relative ROM or on comparison with the opposite limb as all p values were >0

Conclusion: Irrespective of the graft used at one year there was no statistically significant difference between overall Range of Movement, Relative range of movement at 3,6 and one year follow up and functional loss compared to opposite limb (p values>0). We did not find significant differences with the final outcome but the rate of recovery was better with the use of semitendinosus alone hence surgeon may always consider reconstruction using semitendinosus, especially in athletes demanding deep flexion of the knee.

Keywords: Anterior cruciate Tear, ACL Reconstruction, Hamstring tendon harvest, semitendinosus, gracillis, Quadrupled hamstring tendon graft

Introduction

Pes anserinus tendons namely the semitendinosus and gracillis has been a significant source of graft material for reconstruction in the recent years [1] due to their less invasive nature on the donor site during harvest compared to other autografts.

Autograft harvest has been associated with strength deficits in the donor limb with associated loss of range of motion based on the graft used for harvest especially Flexion strength, Active knee flexion and internal rotation loss.

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Noyes *et al.*^[2] reported that a single stranded semitendinosus graft had 49 and gracilis 70 percent the strength of the native ACL but also postulated that the graft would lose its strength during normal healing process. Biological grafts lose their strength during the normal healing process as demonstrated in numerous animal models^[3, 4, 5, 6]. It has been suggested that the mechanical properties of graft strands are additive^[7, 8]. Hence surgeons have attempted to increase strength with use of four-strand hamstring tendon grafts.

Hamstring Muscles the semitendinosus and gracilis have an important role in internal rotation and flexion of the knee. Numerous studies have shown that harvesting the semitendinosus and gracilis reduce knee flexion^[9], especially deep flexion angles^[10] of the knee. Tashiro *et al.*^[11] demonstrated significant loss of hamstring strength and flexion in using both the semitendinosus and gracilis while Adachi *et al.* reported that the peak torque value was not statistically different from a normal knee. In summary the loss flexion increased with harvesting more than one tendon. The gracilis due to biomechanical alterations reinforce the action of the hamstrings during terminal knee flexion despite being a hip adductor, knee flexion alters the insertion of the gracilis with respect to the centre of the knee joint due to the line of pull acting on the muscle.

The gracilis is believed to facilitate anatomic regeneration of the semitendinosus and undergoes compensatory hypertrophy following semitendinosus harvest^[13]. Hence harvesting the gracilis impacts semitendinosus regeneration and decreases post-operative range of movements which points to the fact that harvesting the semitendinosus alone is the best option for reconstruction in athletes who require the high levels of knee flexion strength and a speedy functional recovery from reconstruction^[14, 15].

Following graft harvest the hamstring tendons pass through the neo tendon phase and regenerate within 24 months after surgery but the degree of recovery and redevelopment of semitendinosus was not equal as shown by Leis *et al.*^[16].

The study was aimed at demonstrating recovery of function signifying regeneration potential in the hamstring tendon namely the semitendinosus and gracilis used as graft material for reconstruction procedures. Patients were grouped into 2

namely ST (only semitendinosus used for reconstruction), STG (Both Semitendinosus and Gracilis used for reconstruction). Considering the timing of surgery done and its impact on the recovery of graft regeneration following harvest patient were further grouped into Group I (Reconstruction within 4 months of injury), Group II (Reconstruction within 4 to 8 months of injury) and into Group III (Reconstruction within 8 to 12 months of injury). Recovery hamstring function was noted over a one-year period for each patient.

Materials and methods

The study is retrospective undertaken during a one-year period in the department of orthopaedics at Lourdes hospital, Ernakulam, Kerala starting from March 2010 to February 2011 a total of 101 patients who required reconstructive procedures was included in this study namely arthroscopic ACL Reconstruction as the regeneration and recovery of ROM could be documented by a standard procedure across all the 101 patients. Appropriate consent was obtained from institutional ethical committee and from the patients included in the study.

The patients were selected based on the following inclusion criteria which included males and females between 16 and 60 years who had the ipsilateral semitendinosus or gracilis harvested and underwent primary Acl Reconstruction. Patients with Collateral ligament injury's, posterior cruciate injuries or revision ACL surgeries were excluded, A total of 101 patients were assessed. Data regarding preoperative physical examination, Operative technique, and subjective reports of pain dysfunction or limp were gathered from chart reviews. The age at diagnosis, gender, duration between ACL rupture and reconstruction and also the height, weight and similar complaints in the family were collected

The Gracilis and Semitendinosus tendons can be harvested through an incision centred approximately 4 cm medial and just distal to the tibial tubercle. The required minimum graft length is about 22 cm, because a minimum of 15 mm of quadrupled graft is needed within both the tibial and femoral tunnels^[12]. The initially doubled graft is doubled again to produce a quadrupled construct.

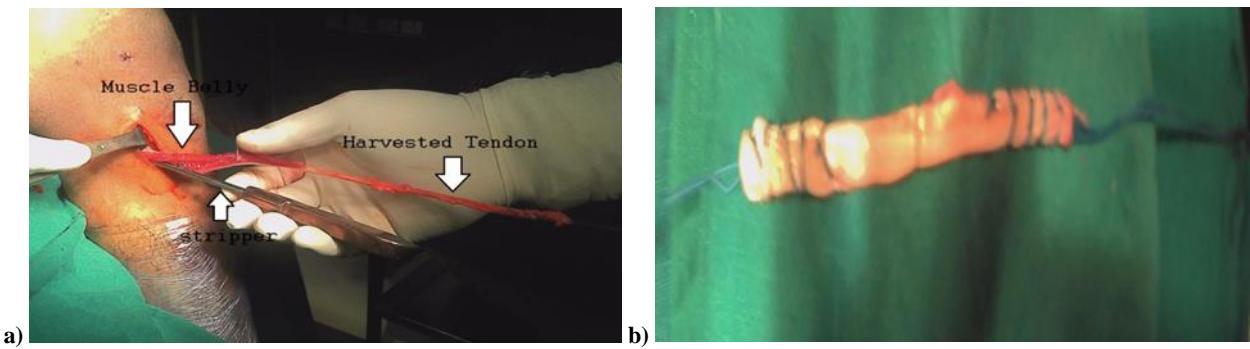


Chart 1: a) Semitendinosus Harvesting using tendonstripper, b) Quadrupled hamstring tendon graft whip stiched

All patients were treated with Arthroscopic ACL Reconstruction. Tendon used for reconstruction were noted and patients grouped into ST group in whom the semitendinosus alone was used for reconstruction and STG group in whom the semitendinosus and gracilis was used for reconstruction. To compensate for the recovery of range of movements associated with acute ACL rupture patients was further grouped based on time of injury to reconstruction. Group I (Reconstruction within 4 months of injury), Group II

(Reconstruction within 4 to 8 months of injury) and into Group III (Reconstruction within 8 to 12 months of injury). The range of motion of the knee was evaluated in the outpatient department when the patients came for review. Measurement was done with the patient supine on an examination bed using a goniometer. The interlimb difference was recorded. Patients were followed up after reconstruction and range of movements assessed at 3 months, 6 months and one year

Statistical Methods

Statistical Methods: The ratio of the patients in the three groups whose data was compared was done using the chi square test. And proportion of patients in each age group distributed across the three groups were verified using Kolmogrov-Smirnov test. The average age of the patients was verified using the F test. and recovery of range of movements across the three groups based on the graft used for reconstruction was analyzed using the t-test and determining the associated P Values.

Results

A total of 101 patients were available for follow up. The patients were grouped into three based on their time of injury to ACL Reconstruction.

Group 1 (Reconstruction within 4 months of injury), Group II (Reconstruction within 4 to 8 months of injury) and into Group III (Reconstruction within 8 to 12 months of injury). The ratio of patient in Group1, Group2 and Group3 is

1:2:2 and it is verified using chi square test as chi square $\chi^2 = 1.2772$ with p value=0.5280>0.05. The study Population included 91 male and 10 female patients. Group1 included 16 male and 5 female patients, Group II 43 male and 2 female and Group III with 32 male and 3 females as shown in table 1.

Table 1: Distribution of patients based on gender across three groups

Sex	Group 1	Group II	Group III	Total
Male	16	43	32	91
Female	5	2	3	10
Total	21	45	35	101
Male %	76	95	91	90
Female %	23	5	9	10

Males constituted 90% of all the patients with injuries and the remaining 10 % females. In group I 76% were male and 23% female, in group II 95% were male and 5% female and in Group III 91 % were male and 9 % female (Table -1).

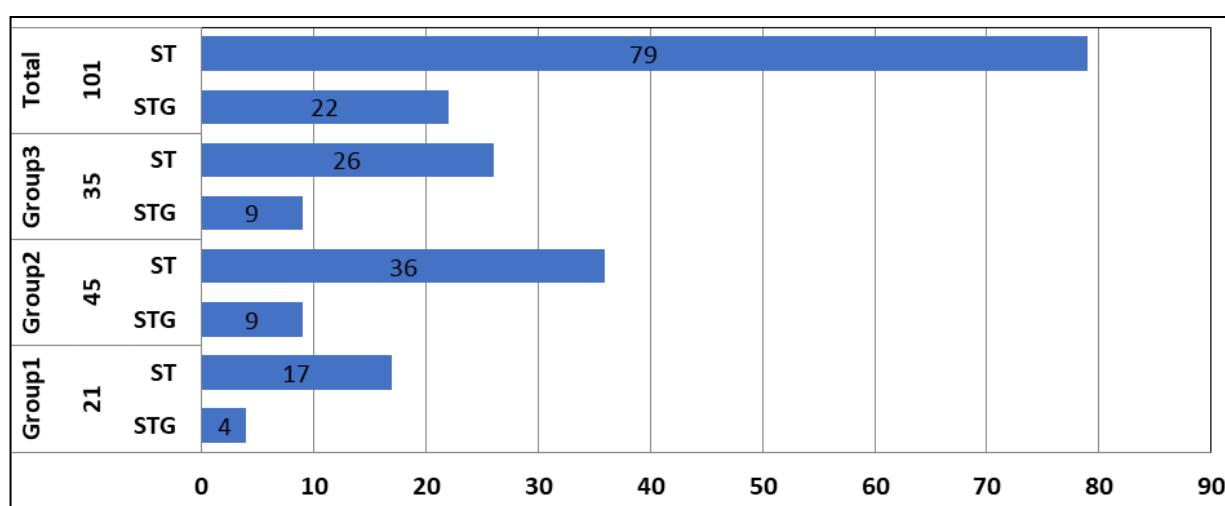


Chart 2: Distribution of cases based on Graft material used for reconstruction

In 79 of the total 101 patients the ACL was reconstructed using the semitendinosus (ST) graft and 22 with both the semitendinosus and gracilis (STG). In group I 26 with ST

and 9 with STG, In group II 36 with ST and 9 with STG In group III 17 with ST and 4 with STG

Comparison of Range of Movements (ROM) in the three groups

Table 2: Relative improvement in ROM Group I

Group1		3 Months	6 Months	1 Year	Relative to opposite Limb
		Post Op	Post Op	Post Op	Pre-Op
4	Min	1.22	1.33	1.33	0.81
	Max	1.43	1.71	1.71	0.89
STG	Aver	1.3	1.5	1.53	0.87
	Min	1.11	1.33	1.33	0.83
17	Max	1.43	1.85	1.85	1
	Aver	1.29	1.47	1.52	0.98
ST	pval	0.93549	0.679545	0.860152	0.112151
	t	0.082019	0.419515	0.178588	1.66582
Group1	Aver	1.29	1.47	1.52	0.99
21	SD	0.08	0.13	0.13	0.16

In group 1 Of the 21 patients 4 belonged to the STG group and 17 to the ST group. In Group I the patients showed a steady improvement with an increase to 29% from first month to third month which progressed to 47% at six months and 52% at one year. At one-year (10/12) 83% of patients belonging to the ST group reached full range of movements compared to the opposite limb whereas in STG group all four

did not achieve full range of movements 3 patients reached 89% and one reached 81%. There was no significant difference in Relative Range of movements (ROM) at 3, 6 or 12 months' time in both ST and STG Patients. (All P values>0.05). As shown in Table 2 and depicted in chart3. The range of movements in Group I Improved steadily with time in all patients who were Operated with ST and STG grafts.

But On comparison of ROM with the opposite limb pre-operative levels STG patients could attain only 87% whereas

ST patients attained 98% results. The Recovery of ROM was better in patients operated with semitendinosus alone.

Table 3: Relative improvement in ROM Group II

Group 2		3 Months	6 Months	1 year	Comparison with Opp Limb
No. of cases		Post OP	Post OP	Post OP	Pre-Op
9	Min	1.07	1.11	1.33	0.74
	Max	1.33	1.67	2	0.93
STG	Aver	1.19	1.25	1.5	0.85
36	Min	1.11	1.22	1.22	0.91
	Max	1.57	1.83	1.93	1
ST	Aver	1.3	1.51	1.56	0.96
	pval	0.032562	0.05559	0.949968	0.599924
	t	2.208867	1.967566	0.063114	0.528421
Group2	Aver	1.28	1.48	1.56	0.94
45	SD	0.137422	0.178585	0.18195	0.09

In group II of the 45 patients 9 belonged to the STG group and 36 to the ST group. There was a steady improvement in the overall range of movements which increased gradually attaining 28 % at 3 months, 48% at six months and 56% at the end of one year. But On comparison of ROM with the opposite limb pre-operative levels in ST patients (20/33)61% reached 100%, 7 reached 96%, 5 reached 90% and 1 patient 83%. Whereas in STG patients 6 reached 90% and the

remaining 3 patients attained 81%, 78% and 74% respectively. There was a significant difference in the relative improvement of ROM at 3rd month ($p<0.05$) between patients operated with ST and STG as shown in table 3 and chart 4. Pt operated with ST alone showed significant improvement, but there was no difference at 6th Month or 1-year time (other P Values>0.05). In comparison with opposite limb Patients attained more than 90% Rom in ST group compared to STG.

Table 4: Relative improvement in ROM Group III

Group 3		3 Months	6 Months	1 Year	Comparison with Opp Limb
No. of cases		POST-OP	POST OP	POST-OP	Pre-Op
9	Min	1.11	1.22	1.22	0.77
	Max	1.42	1.71	1.78	0.92
STG	Aver	1.19	1.37	1.39	0.85
26	Min	1.11	1.33	1.38	0.88
	Max	1.57	1.92	1.93	1
ST	Aver	1.26	1.54	1.6	0.97
	pval	0.139332	0.009496	0.002226	2.3E-08
	t	1.514845	2.75423	3.316416	7.28964
Group3	Aver	1.25	1.5	1.55	0.94
35	SD	0.13	0.18	0.19	0.07

In group III of the 35 patients 9 belonged to the STG group and 26 to the ST group. ROM increased steadily from 1st month to 3rd month at 26% in ST group and 19% in STG patients. And from 3rd months to 6th months at 28% and 18% respectively while at 1 year there was a change of 6% and 2% respectively. Overall improvements in ROM in Group III showed 25% change in 1st to 3rd month, 50% in sixth months and 55% at 1 year. The relative improvement of ROM was

less in third month (P value>0.05). But there was a significant improvement at 6th month and one year in both ST and STG group (P values<0.05). But On comparison of ROM with the opposite limb pre-operative levels in ST patients 13/21 (62%) reached 100%, 6 reached 96%, 2 reached 90%. Whereas in STG patients 5 reached 90% and the remaining 2 patients attained 81%, 78%. As shown in table 4 and chart 5.

Table 5: Comparison of relative ROM between Group I, II and III

Between		3 MONTHS	6 MONTHS	1 YEAR	relative to opposite limb
G1 G2	Pval	0.70581	0.846014	0.4487124	0.513558
	t	0.379178	0.194995	0.76224759	0.656966
G1 G3	Pval	0.14496	0.571931	0.60270546	0.122755
	t	1.478966	0.56868	0.52359079	1.567864
G2 G3	Pval	0.314056	0.728418	0.78407221	0.982597
	t	1.014255	0.348665	0.27510178	0.021893

Statistically significant difference between relative Range of Movement was not found in Group I, II or III at 3 months 6 months or 1-year follow up period and also in comparison

with the opposite limb as all p values were >0. Depicted in table 5.

Table 6: Comparison of Overall ROM between 3 groups

comparison	Between	Z	P Value
ST	1Vs2	1.0835	0.27 85
ST	1Vs3	0.3124	0.7547
ST	2Vs3	0.9123	0.3616
STG	1 Vs 2	1.0353	0.3009
STG	1 Vs 3	1.8142	0.0696
STG	2 Vs 3	0.9925	0.3209
Group1	STG Vs ST	0.5933	0.5529
Group2	STG Vs ST	0.1614	0.8717
Group3	STG Vs ST	2.4623	0.0138<0.05
All	STG Vs ST	0.2555	0.7982

Mean range of movements in patients operated with Semitendinosus and Gracillis was found to be less than in those operated by Semitendinosus alone.

At one year, no statistically significant difference was found between patients in the STG group on comparison with ST group. Depicted in table 6.

Discussion

Outcome on ROM associated with Graft material used for reconstruction.

Comparison of Range of movements in Group I, II, and III showed no significant loss of range of movements using either semitendinosus and Gracillis or semitendinosus alone at one-year post rehabilitation. Even though the recovery of ROM (Relative ROM) in patients who was operated with semitendinosus alone was better initially at 3-month and 6 months.

In Group I the relative ROM improved steadily from 3rd month to 1 year in all patients irrespective of the graft used. Rate of recovery was better in ST compared to STG. On Comparison with the opposite limb STG patients reach 87% pre op levels whereas ST patients reached 98%. In Group II There was a significant difference in the relative improvement of ROM at 3rd month, between the two groups (ST, STG). Pt operated with ST alone showed better recovery, but there was no significant difference after six months of follow up whereas In Group III there was a significant difference in the relative improvement of ROM even up to six months and one year between the two groups (ST, STG). The recovery of ROM was slower in patients in the STG group (19%) compared to ST (26%)

There was an overall poor recovery in patients operated with both the semitendinosus and gracillis (STG) graft compared to patients operated with semitendinosus alone (ST). The use of hamstring tendons resulted in loss of knee flexion as shown by Eriksson *et al.* 2001 [17] and Yasuda *et al.* [18] However, knee flexion shows considerable recovery during the first postoperative year. Range of Movements in patients operated with a Semitendinosus graft alone was better than patients operated with Semitendinosus and Gracillis which gradually improved over time. Also, the Relative improvements of ROM was better in patients operated with ST alone as they recovered their Rom significantly within 3 months ($p<0.05$) but there was no statistically significant difference at 6 months and one year (other P values>0.05).Use of both Semitendinosus and Gracillis resulted in lack of deep flexion of the knee but the loss recovered with time.

Conclusion

We did not find significant differences with rate of recovery when both the semitendinosus and gracillis was used and also

when the semitendinosus alone was used at one year follow up but the but the rate of recovery was better with the use of semitendinosus alone. Harvesting the Semitendinosus alone or Semitendinosus and Gracillis for reconstructive procedures offered good clinical results but Using both Semitendinosus and Gracillis resulted in greater loss of knee flexion hence surgeon may always consider reconstruction using semitendinosus, especially in athletes demanding deep flexion of the knee. Irrespective of the graft used at one year there was no statistically significant difference between overall Range of Movement, Relative range of movement at 3,6 and one year follow up and functional loss compared to opposite limb (p values>0).

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