

# Functional Outcome of Tripled Semitendinous Autograft for ACL Reconstruction: A Retrospective Study

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## Abstract

Hamstring tendons have become the most accepted grafts for ACL reconstruction. Harvesting only semi-T instead of semiT-G from the pes anserinus can reduce the deficit of the knee flexor strength and improve the functional recovery without weakening the reconstructed ligament. A Retrospective study was conducted on 63 patients who underwent anatomical ACL reconstruction using tripled semitendinosus graft fixed with interferential screws. The average length of the semitendinosus graft was 25cm. The cases had an average follow up upto 24 months. Functional evaluation informs radiological laxometry and objective knee scores in the forms of IKDC, Lysholm and Tegner scores. The mean Lysholm score improved from 49 (35-65) pre-op to 86 (55-100) on follow-up. The Tegner score improved from 4+1 to 5+1. The IKDC (International knee documentation committee) score improved from pre-op A=2cases, B=7, C=15, D=39 to Post-op A=28, B=22, C=10, D=3 respectively. 4 cases have pivot shift positive (6%) including 3 cases of traumatic graft ruptures at a mean age of 9.3 months. After radiological laxometry, 48 cases have anterior laxity <3mm, 6 cases have 3-5mm and 4 cases have >5 mm laxity. Tripled ST graft is an adequate graft for ACL reconstruction in the Indian population, considering the varied anthropometry and squatting habit. It obviates the need for harvesting the gracilis, yet retains adequate strength for use as an ACL graft.

**Keywords:** Tripled Semi Tendinosus graft; Knee scores; Gracilis.

## Introduction

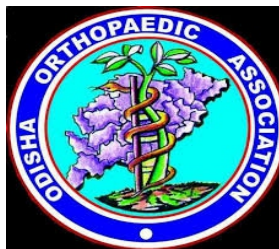
Anterior cruciate ligament reconstruction using autogenous semitendinosus and gracilis tendon has become a common procedure because these grafts are thought to provide less quadriceps weakness, anterior knee pain, and donor-site morbidity compared with other grafts [1, 2]. Although the primary function of the hamstring muscles is to flex the knee or to decelerate extension of the knee, the hamstring muscles also regulate rotation of the tibia and, more importantly, control anterior translation of the tibia, sharing the stress with the ACL [10]. Each hamstring graft configuration has advantage and disadvantages. ST-G (Semi tendinosus-gracilis) graft technique is familiar to many surgeons and yields sufficient length of graft without having concern for graft length at end for secure fixation. The disadvantages are possibility of gracilis sacrifice. Typical morbidity after hamstring graft harvest is decreased strength in knee flexion and tibial rotation[10]. Proprioceptive studies have also shown that greater knee flexor strength and stability is important in both ACL deficient and reconstructed knees for improved function [11]. The ST graft technique(tripled) has advantage to preserve the gracilis strength. Some authors recommend harvesting only the semitendinosus tendon to minimise morbidity [4, 6]. Others have

not found any significant differences in hamstring strength during flexion when a harvest of both the semitendinosus and gracilis tendons (ST/G) was compared with a harvest of only the semitendinosus tendon (ST) [12, 13]. The main drawback with the ST graft is that the tendon length might not be adequate for fixation of the tendon in the bone tunnels [6].

The minimum length of the ST tendon for quadrupling it to get an effective graft diameter and length is 28 cm, which is very unusual to get in our clinical practice. In such a situation, the available options are either to sacrifice the Gracilis or to go for tripling the available ST. This study aim to comprehensively study and evaluate functional outcome of ACL reconstructions using a tripled semitendinosus tendon graft (ST), using subjective outcome scores, measures of knee laxity, functional outcome. we hypothesized that tripled ST graft has more benefits in terms of hamstring strength, anterior knee laxity and patient related outcomes.

## Materials & Methods

A retrospective study conducted after prior approval by the Institutional ethical committee. Out of 110 symptomatic ACL injury cases presented to our hospital from Jan 2014 to Jun 2017, 63 cases were taken on whom ACL reconstruction (tripled ST) done. All are young, active cases (age group 20-40 yrs, mean of 28.2 yrs) with normal opposite knee gave informed consent for the study. Multi ligamentous injuries, revision ACLR, grade 3/4 chondral changes, any previous knee surgeries except meniscectomies and diagnostic arthroscopy are excluded from the study group. The clinical, radiological examination findings, respective Pre-op IKDC, Lysholm and Tegner scores are collected from the case records. All the cases are



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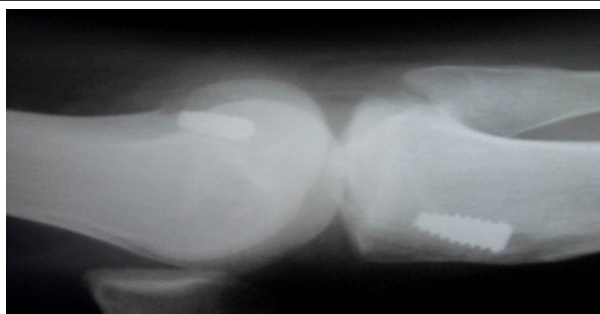
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**Figure 1 :** Tripled Hamstring graft  
(from Book of Proddimos . The Anterior Cruciate Ligament, Reconstruction and Basic Science)



**Figure 2 :** Intra Operative pic of Tripled Semitendinosus Graft



**Figure 3 :** Interferential screw fixation on both side

operated after minimum of 3 week of injury, by a single operating surgeon. The surgical procedure is anatomical ACLR by tripled ST (Figure 2), fixed by Interferential screws at both the ends (Figure 3). A strict, uniform post ACLR rehabilitation protocol followed for all the cases. Patients are allowed for unrestricted sporting activity after minimum of 80% of hamstring and quadriceps power regained compared to opposite limb. From the OT notes, the intra op ST length and the graft diameter after preparation was collected. Cases were followed up for functional evaluation upto 24 months (Table - 2). 9 cases lost to follow up. Follow up examination done by single examiner. Physical examination includes assessing ROM of both (affected and healthy) knee joints by goniometer, physical tests like anterior drawer, lachman and pivot shift tests. Radiological laxometry was done to document the antero-posterior laxity. All the patients completed the questionnaires to determine the respective IKDC, Lysholm and Tegner outcome scores.

The collected data were processed with SPSS software. To analyse normally distributed categorical variables Chi square test was performed. To analyse normally distributed quantitative variables it has been performed the parametric t-Student test. For the nonparametric test it was used the Mann-Whitney U-test. Differences were considered significant if p-value was  $< 0.05$ .

Anterior laxity	Pre-op (no. cases)	Post-op (no. of cases)
<3 mm	5	51
3mm-5mm	34	8
>5mm	24	4
<b>IKDC</b>	<b>Pre-op</b>	<b>Post-op</b>
A(normal)	2	28
B(Nearly normal)	7	22
C(abnormal)	15	10
D(Severely Abnormal)	39	3
	<b>Pre-op</b>	<b>Post-op</b>
<b>Lysholm score</b>	49(35-65)	86(55-100)
	<b>Pre-op</b>	<b>Post-op</b>
<b>Tegner score</b>	4 $\pm$ 1	5 $\pm$ 1

**Table 1:** Results of our study taking into account subjective assessment in form of radiological laxometry and objective scores in form of Lysholm, tegner and IKDC scores.

## Results

Sixty-three patients (38 male and 22 females) were available for the detailed examination at an average of 3.4yrs follow-up. Of 63 cases, 51 (79%) had recreational sporting activity, and the rest 12 cases had some level of professional sports activities. The intra op ST length was avg 25 cm (22-31cm). The average diameter of the tripled ST graft after preparation was 7.5 mm proximal and 8 mm distal. All the patients had a good active and passive range of motion, except 7 cases (11%), of which four cases had FFD  $< 5^\circ$  (fixed flexion deformity) and 3 cases had terminal restriction of flexion movement compared to opposite limb. At follow up four cases had pivot shift positive (6%) including 3 cases of traumatic graft ruptures. After radiological laxometry (Table-1), 51 cases have anterior laxity  $< 3$  mm, 8 have 3-5 mm and 4 cases have  $> 5$  mm laxity. The mean Lysholm score after minimum of 2 yr post ACLR, improved from 49 (35-65) pre op to 86 (55-100) on follow up. The Tegner activity score improved from 4 $\pm$ 1 to 5 $\pm$ 1. The IKDC score (Table-1) improved from pre op A=2, B=7, C=15, D=39 to A=28, B=22, C=10, D=3. Chi square analysis shows statistical significance (P value  $< 0.05$ )

Out of 2 cases showing features of infection, one required arthroscopic irrigation along with aggressive medical treatment. The other one diagnosed as a case of post-op sterile reactive effusion. Both the cases improved by 3 weeks post-op. Two instances of inadvertent intra articular IF screw extension encountered which was managed by readjustment again. Three cases landed up with graft rupture following re-injury after a mean age of 9.3 months. Graft site anaesthesia incidence improved from 9 cases immediate post-op to 3 cases at present follow up.

## Discussion

our study shows that harvesting tripled hamstring with adequate length and size having good functional and clinical outcome. The decision to harvest semitendinosus-gracilis or tripled

semitendinosus graft include consideration of issues other than range of knee rotation and harvest-related morbidity such as hamstring strength. Prodromos [3] has listed some concerns relevant to the decisions a surgeon has to make regarding the hamstring graft construct, specifically, graft length in the tunnels, preferred fixation method, the need for gracilis harvest or not and graft strength. Gobbi [4] in 2010 have proposed that a semitendinosus tendon length of at least 28 cm is required to have enough graft length in the tunnels to do a four-strand semitendinosus ACL reconstruction. He also suggested avoiding removal of gracilis whenever possible due to associated morbidities. Prodromos [3] in 2007 found out hamstring graft strengths according to Noyes study, the ST being 70% strength of natural ACL, Gracilis 49%, whereas the 4 ST graft would be 280%, a 2ST+2Gr would be 238% and a 3ST graft would be 210%.

In our study we did not harvest gracilis which in many studies [7, 8, 9] shown loss of flexion strength in higher flexion angles. The weakness seen when the gracilis is used for graft in addition to the semitendinosus could be explained by functional and anatomic features of the gracilis. The gracilis muscle is crucial for maintaining the normal biomechanics of the knee joint. Viola et al [5] reported that the harvest of gracilis muscle tendons may also cause internal tibial rotation weakness since this muscle is not only primary knee flexor but also primary tibial internal rotator. Therefore, a gracilis tendon harvest can impair the “screw home” mechanism occurring at the end of knee extension. Screw-home mechanism impairment could explain decreases in knee flexion strength in the gracilis graft group. Naskamura et al 2002 [15] showed that removing gracilis for the composite graft results in a significant loss of deep flexion strength and internal rotation torque weakness.

Interestingly, in our study the average length of ST is 25 cm, which relatively smaller than the required for getting an effective 4ST graft. This variation may be because of anthropometric variations like short stature compared to western counterparts. Grehen Treme et al (Am. J. of Sports Med. 2008) have also found a correlation between the height of the person with the length of the ST graft. It is difficult to compare the existing studies about various hamstring graft combinations because of different surgical procedures and rehabilitation protocols. Prodromos et al. [3] suggested that screw type (endo button/tibial screw), surgical procedure (number of the loops or aggressively pre-tensioned grafts), and aggressive postoperative rehabilitation can cause laxity.

Tashiro et al [6] in their research demonstrated that harvest of the hamstring tendons impairs knee flexion strength at higher flexion angles. However, it is also true that a satisfactory result was obtained in most of these patients. This could be because the function of the hamstring's function is more critical at extended or slightly flexed knee positions [5], and forceful contraction at higher flexion angles is rarely required, with notable exceptions for specific actions in several athletic activities. Therefore, considering the advantages and disadvantages of the hamstring tendon graft method and other reconstruction methods, we believe choosing the best procedure for ACL reconstruction in athletes may depend on the types of athletic activity in which they participate.

Lipscomb et al [19] revealed that overall hamstring performance concerning to knee flexion was not affected when the semitendinosus alone, or when both semitendinosus and gracilis were used to reconstruct the anterior cruciate ligament. Hamstring and quadriceps strength of each patient's normal and reconstructed knee

Authors	Year	Study Design	Cohort	Type of graft	Clinical evaluation	Difference in Strength recovery
Ardern et al.	2010	Retrospective cohort study, level 3	50	4STvs 2GST	No difference in clinical evaluation	No differences
Yosmaoglu et al.	2011	Prospective cohort level 2	46	STvs GST	No in side-to-side difference in anterior tibial translation	Higher side-to-side difference in knee flexor torque in GST at 60°
Barenus et al.	2013	Retrospective cohort study, level 3	20	4STvs 2GST	No difference in stability and CO	No differences
Inagaki et al.	2013	Prospective cohort level 2	120	Double-Bundle technique: 4STvs 2GST	No difference in CO and subjective score	No differences
Kentel et al.	2015	Retrospective cohort study, level 3	60	2STvs GSTvs Control Group	Not assessed	No strength differences. Influence of gracilis harvest in the deep internal shin-rotation torque
Sharma et al.	2016	Systematic Review level I-III studies, level III	12 studies	ST-harvest vs GST-harvest (Various folding)	No difference in stability and CO	Active knee flexion loss. Reduced strength at 60°/s in GST group

**Table 2:** Results of the literature concerning the muscle strength in hamstring graft selection. ST, semitendinosus; GST, gracilis + semitendinosus; 2, double; 3, triple; 4, quadrupled; CO, clinical outcomes; °/s, degree per second; RCT, randomized controlled trial



was evaluated using a Cybex machine. This machine is an isokinetic dynamometer equipped with a pen recorder that provides a continuous printout of torque (in foot-pounds) developed throughout the range of motion of the joint being tested. Yosmaoglu [20] suggested that additional harvest of gracilis did not influence lower extremity motor control, quadriceps muscle torque, and anterior tibial translation; however, it affected knee flexion isokinetic torque negatively at low angular velocity. This finding could be important for functional activity or sports with high demands on hamstring muscle strength.

The non-traumatic laxity in form of positive pivot shift test in ours is 1% compared to 4% in studies by Williams et al [21]. This low incidence can be explained by the fact that, we have adopted non-isometric placement of femoral tunnel, contrary to isometric placement in other studies. Strengthening the knee flexors (specifically the hamstrings), eccentrically and concentrically, is therefore crucial in rehabilitation programs for at least the 12 months following surgery.

Our study has some limitations. This is a retrospective study with a small duration of follow up. We do not have our own group of composite graft ACLR for comparison. There is no biomechanical

testing of tripled hamstring graft done. A comparative study with four-stranded graft is essential. No attempt was made to assess the knee internal rotation performance. A Randomized Control Trial is the best method to confirm this hypothesis. Rehabilitation protocol for athletes and non-athletes should have been assessed.

## Conclusion

Although, strength-wise, 4ST/2ST+2G grafts are the best, but considering the varied anthropometric characteristics of Indian populations, frequent habit of squatting, requiring high internal torque in sports, tripled hamstring (Semi-tendinosus) graft can be used as an effective hamstring graft construct in ACL reconstruction. The functional knee scores were significantly increased at the time of follow-up after harvesting tripled hamstring graft. Moreover, saving the gracilis tendon is sometimes associated with a minor deficit of strength in flexion.

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