

# Nerve injury during hamstring graft harvest: a prospective comparative study of three different incisions

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## Abstract

**Purpose** To compare the incidence, extent of sensory loss, its clinical effect and natural course caused by three different skin incisions used for autogenous hamstring graft harvest during anterior cruciate ligament (ACL) reconstruction.

**Methods** One hundred and twenty patients who underwent hamstring graft harvest during ACL reconstruction, participated in the study. All patients were randomized into 3 groups as per the 3 incisions used—vertical, transverse and oblique. The area of sensory loss was documented as per anatomical distribution of the infrapatellar branch of saphenous nerve (IPBSN) and sartorial branch of sensory nerve (SBSN) at 6 weeks, 3 months and 6 months follow-ups. The length of incision, area of sensory loss and subjective pain score (out of 10) were also noted.

**Results** The incidence, area of hypesthesia and persistence at 6 months were significantly higher with vertical incision at all times, whereas it was the least with oblique incision. Injury to IPBSN was maximum with vertical incision ( $p = 0.000$ ), and it was similar in the transverse and oblique incision groups. The SBSN injury incidence was not significantly different between the three groups (n.s.). Subjective cutaneous hypesthesia incidence was quite low in all the three groups. The oblique incision group had highest subjective satisfaction closely followed by the horizontal incision group.

**Conclusions** Vertical incision has highest incidence of IPBSN injury, persistent hypesthesia, largest area of sensory loss and poorest subjective outcome. Oblique and

transverse incision groups had statistically comparable results, though better outcome was noted in the oblique incision group. The SBSN injury was equally common in all the three incisions used. However, the sensory loss does not impair normal daily activities in the patients. We recommend use of oblique incision for hamstring graft harvest.

**Level of evidence** Therapeutic randomized controlled prospective study, Level I.

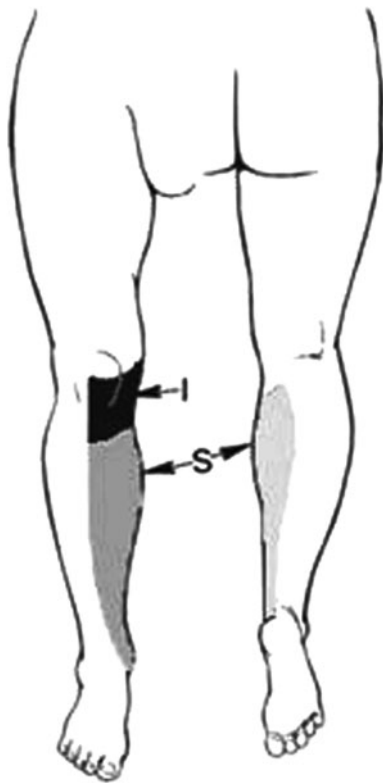
**Keywords** Hamstring · Saphenous nerve · Infrapatellar branch · Sartorial branch

## Introduction

Autogenous hamstrings are popular graft source for anterior cruciate ligament (ACL) reconstruction. In meeting patient expectations, harvesting technique for autogenous hamstrings is becoming increasingly minimally invasive. The proximity of the semitendinosus and gracilis tendon insertion sites to the saphenous nerve and its branches, variable tendon morphology, and variable adipose tissue volume necessitates effective surgical incision placement to minimize tissue morbidity during graft harvest [2, 4, 7, 10, 13, 27].

The saphenous nerve supplies cutaneous sensation of the medial aspect of the knee, lower leg and ankle [2] (Fig. 1). The saphenous nerve arises from the posterior division of the femoral nerve in the proximal thigh, where it lies lateral to the femoral artery. It then enters the adductor canal where it courses medially over the femoral artery. On exiting the canal with the saphenous branch of the inferior geniculate artery, the nerve promptly divides into its two terminal branches: the IPBSN and the SBSN. The IPBSN

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**Fig. 1** Sensory innervations of the saphenous nerve in the leg; “I” is the area innervated by the infrapatellar branch (IPBSN), and “S” is innervated by the sartorial branch (SBSN)

travels anteriorly and divides further into superior and inferior trunks to supply the anteromedial aspect of the knee. The SBSN takes a vertical course as it travels down the medial knee behind the sartorius in close association with gracilis over a length of few centimetres before becoming subcutaneous by piercing the fascia. It then continues distally with the great saphenous vein to govern sensation of the medial aspect of the leg and ankle [1, 9, 20, 26].

Placement of incision over pes anserinus can injure the cutaneous nerves locally. Also, blind hamstring harvest through a mini-incision carries a risk of nerve injury, from either direct transection during release of accessory insertions or blunt trauma during passage of the tendon stripper between layers I and II of the medial aspect of the knee [20].

A literature review did not reveal a standard incision method for semitendinosus–gracilis tendon harvest. Friedmann [7] stated that the tendon harvest incision should be placed 1 inch medial to the tibial tuberosity and then a vertical incision should be placed 3 inches distal. Brown et al. [4] preferred an oblique incision placed along the lines of the creases at the superior aspect of the pes anserinus because it allowed for the skin to be retracted parallel to the orientation of the semitendinosus and

gracilis tendons, providing better exposure and a more cosmetic scar. Marder et al. [13] recommended making a 4-cm oblique incision over the pes anserinus insertion, approximately 3 finger breadths below the medial joint line to adequately identify the semitendinosus and gracilis tendons. Yasuda et al. [27] used a 4-cm-long incision through the pes anserinus insertion, then split the membranous insertion of the sartorius parallel with its fibre orientation and detached the semitendinosus and gracilis tendons from their tibial insertions through this slit before harvest. Pagnani et al. [18] measured the insertion point of the conjoined structure and the anteromedial tibial surface and reported a mean location 1.9 cm distal to and 2.25 cm medial to the apex of the tibial tuberosity and suggested a figure-four position during harvesting to relax tension on the saphenous nerve as it passes over the gracilis at the posteromedial joint line. Tilette et al. [25] suggested a diagonal incision originating 3 cm medial to the tibial tuberosity and terminating at a point 3 cm distal and 5 cm medial to the tibial tuberosity effectively exposes the junction at which the semitendinosus and gracilis tendons bifurcate to become distinct structures.

Both IPBSN and SBSN injury, even saphenous nerve injury, are well reported with hamstring graft harvest [5, 8, 12, 16]. However, most of these reports focus on the vulnerability of the IPBSN only. Spicer et al. [22] reported that after a 2-year follow-up, 50 % of patients had disturbed sensation in the anterior knee, and 86 % of these were found in the area innervated by IPBSN. Soon et al. [21] found that at 6 months of follow-up, 4 % of patients had injury to the saphenous nerve or its branches. Mochizuki et al. [16] described sensory disturbance in 58 % of arthroscopic ACL reconstructions. Sanders et al. [20] found 19 % prevalence of isolated injury to the IPBSN and a 32 % injury rate to both the IPBSN and SBSN due to hamstring graft harvest, but isolated SBSN injury rate was 23 %. Figueroa et al. [6] noted hypesthesia in IPBSN distribution in 77 % cases of which 68 % cases had injury to IPBSN on electrophysiological study.

Anatomical studies have identified safe zones for making incisions to minimize neural injury while harvesting hamstrings graft [3, 15, 20]. But clinical comparative studies are very few in number, have compared two types of incisions only with smaller study groups to prove the advantage of any particular incision [8, 19]. Hao et al. [8] compared vertical and oblique incisions, whereas Papatergiou et al. [19] compared vertical and transverse incisions in their studies.

The purpose of this study is twofold: (1) to compare the incidence and extent of injury to the IPBSN and SBSN by placement of three different incisions for harvest of hamstring grafts, and (2) to study the clinical effect and the natural course of the sensory deficit.

## Materials and methods

In this randomized controlled prospective study of consecutive series, all subjects were informed of the study procedure, the purposes of the study and any known risks; and all provided written informed consent authorizing the treatment and photographic documentation. Appropriate approval of the hospital ethical committee was granted.

One hundred and fifty-two consecutive patients were diagnosed with ACL rupture and underwent ACL reconstruction by single surgeon (V.K.) between 2005 and 2008. The patients who were above 55 years or below 20 years, or had concomitant ipsilateral ligament injury, or medial meniscal repair, or previous knee surgery, or neurological disorder were excluded. One hundred and twenty patients participated in the study and were randomized by sealed and numbered envelopes into 3 groups, with 40 patients in each group; the patient as well as the physiotherapist being blinded to the group patient belongs to. Strict concealment of the treatment allocation was fulfilled. Eight patients did not complete the study protocol due to migration so excluded. The patient characteristics are comparable between the groups (Table 1).

### Surgical technique

The hamstring tendons were palpated over the pes anserinus medial to the tibial tubercle. A 4 cm incision was made over the pes anserinus; transverse incision in group A, horizontal incision in group B and oblique incision in group C. The oblique incision was given in the safe area as recommended by Boon et al. [3] on the tibial tuberosity plane between 3.7 and 5 cm from joint line with a safe angle of incision of 50°.

The gracilis and semitendinosus tendons were identified by digital palpation. The sartorial fascia was split along the fibre direction and the tendons were isolated by blunt dissection. The fascial strands of semitendinosus tendon to medial gastrocnemius were cut under vision and an open ended tendon stripper was used to harvest the graft. The tibial attachments of the tendons were detached with sharp knife.

ACL reconstruction was performed by single incision arthroscopic method using standard instrumentation (Smith & Nephew Endoscopy, Andover, MA). Tibial tunnel was drilled using a jig fixed at 55° through the same incision. Femoral tunnel drilling and fixation were performed through the anteromedial portal. Quadrupled hamstring graft was fixed with Endobutton CL on the femoral side and bioabsorbable screw (BIORCI, Smith & Nephew Endoscopy, Andover, MA) on the tibial side.

### Rehabilitation

A semi-conservative rehabilitation protocol was followed, with emphasis on early restoration of full extension and quadriceps function. Partial weight bearing was started immediately and progression was on an as-tolerated basis. Patients were allowed to ride exercise bicycles at 6 weeks. Closed kinetic chain quadriceps exercise was continued during the first 3 months. A hinged knee brace was used during the first 3 months. Running was allowed at 3 months, with return to full activities after 6 months. High-level sporting activities were permitted after 12 months.

### Clinical evaluation

All patients were evaluated was by one of the authors (D.S.) at 6 weeks, 3 months and 6 months. Detailed clinical examination and functional assessment were performed with the International Knee Documentation Committee (IKDC) 2000 Subjective Knee Evaluation score, and a comparison was made with the preoperative status. Anteroposterior and lateral radiographs were also evaluated for tunnel position and enlargement.

The incision length was measured in cm for every patient. The subjective area of sensory loss was tested with patient sitting with both legs extended. A blunt pin was used for pin prick examination starting from the proximal end of the incision and then moving superiorly and laterally, and the patient was asked to note the point of change in sensation from abnormal to normal, and it was marked with a skin marking pen. The next such point was identified within 0.5 cm of the first, and the process was continued till the superior, lateral and then the inferior extent of the sensory loss is demarcated reaching back to the inferior end of the incision. The points were joined with small straight lines. Then, a transparent polyethylene sheet of adequate size was placed over the marked area and the marking over the skin was traced to it. The transparent sheet was then put over a graph paper, and the area was calculated to an accuracy of one decimal. Digital photographs of such areas of hypesthesia were also taken and analysed with Adobe photoshop Elements 2.0.

**Table 1** Characteristic of the participants in the ACL incision study

	Vertical ( <i>n</i> = 38)	Horizontal ( <i>n</i> = 37)	Oblique ( <i>n</i> = 37)	<i>p</i> value
Female: no. (%)	3 (7.9)	3 (8.1)	2 (5.4)	n.s.
Age (year): mean ± SD	30.6 ± 9.4	32.4 ± 8.7	31.5 ± 9.1	n.s.
Side: left (%)	21 (55)	26 (70)	24 (65)	n.s.



**Fig. 2** A typical area of hypesthesia in a patient with vertical incision used for hamstring harvest, located over lower part of the incision and extending laterally over and lower to tibial tuberosity corresponding to the distribution of IPSBN, also extending to the shin obliquely downwards and then to the anterolateral side of the leg corresponding to the area of innervations of the SBSN

### Statistical analysis

For statistical analysis, we used InStat software for Windows (GraphPad, version 3.00; GraphPad Software, San Diego, CA). The chi-square test or Fisher exact test was used to compare the categorical variables between the three groups, with the plan of further pairwise testing in case of significance on the global test. The quantitative data in the three groups were analysed using the Kruskal–Wallis test, with the plan of further pairwise testing using Mann–Whitney *U* test in case of significance on the global test. The *p* values were corrected for multiple testing using the procedure of Bonferroni–Holm. However, for conventional purposes, we report the uncorrected *p* values and compare them to the corrected ones. Hence, a corrected *p* value of <0.05 was considered as statistically significant.

### Results

At 6 months, vertical incision was associated with persistent sensory loss in 79 % (30/38) cases which was significantly higher ( $p = 0.001$ ), when compared to the horizontal and oblique incision groups. The IPSBN injury incidence was significantly high in patients of vertical incision group ( $p = 0.000$ ), whereas it was nearly similar (n.s.) in transverse and oblique incision groups. SBSN injury incidence was not significantly different between the three groups (n.s.) (Table 2).

The measured area of hypesthesia was significantly higher in the vertical incision group followed by the horizontal incision group, and it was the least in the oblique incision group at all times (Table 3). In most patients, the area of cutaneous area of hypesthesia was located over lower part of the incision and extending laterally over and lower to the tibial tuberosity corresponding to the distribution of IPSBN (Fig. 2), many a times also extending to the shin obliquely downwards and then to the anterolateral side of the leg corresponding to the area of innervations of the SBSN. On further follow-ups at 3 and 6 months, the area of hypesthesia gradually shrunk in size. The recovery followed a pattern: from distal to proximal in direction. At 6 months in most cases, a persistent area of sensory loss was usually located close to the incision only which continued to be present on further follow-up (average 18 months; range: 14–32 months). No incidence of saphenous nerve injury, neuralgia or reflex sympathetic dystrophy was noted in any of the patients.

Subjective cutaneous anaesthesia incidence was quite low in all groups, though significant difference was found between the vertical and oblique incision groups ( $p = 0.006$ ). Most of the patients were either unaware or not bothered by the cutaneous hypesthetic area. The patients with larger area of hypesthesia and those with anaesthetic area over IPBSN distribution were more aware of the problem. Oblique incision group had highest subjective satisfaction closely followed by horizontal incision group. Patients with vertical incision had least subjective satisfaction rate (Table 2).

### Discussion

The most important finding of the present study was that hamstring graft harvest by oblique incision was associated with least incidence of IPSBN injury and superior subjective outcome. However, injury to SBSN is not affected by the type of incision used. In this study, vertical incision group was always associated with some numbness (100 %) at 6th week. It was 73 % (27/37) and 67.5 % (25/37) in the transverse and oblique incision groups, respectively. At 6 months, vertical incision was associated with persistent sensory loss in highest number of cases, whereas it was nearly similar in the horizontal and oblique incision groups, respectively. Out of all, 20 % (22/112) of patients showed improvement by 6 months. This observation is in line with most of the authors [2, 19–22] that the nerve damage was present after 6 months and likely permanent in nearly 80 % cases. Similarly, hypesthesia in SBSN distribution was present in 47 % (53/112) at 6 weeks, of which 17 % (19/112) patients recovered completely. The overall incidence of SBSN injury was comparable in the three groups.

**Table 2** Outcomes of incision surgery by group

	Vertical ( <i>n</i> = 38)	Horizontal ( <i>n</i> = 37)	Oblique ( <i>n</i> = 37)	<i>p</i> value
<i>Number of patients with numbness</i>				
6 weeks	38	27	25	0.000 V & H, <i>p</i> = 0.001* V & O, <i>p</i> = 0.000* H & O, n.s.*
6 months	30	16	14	0.001 V & H, <i>p</i> = 0.002* V & O, <i>p</i> = 0.000* H & O, n.s.*
<i>IPBSN</i>				
6 weeks	36	21	19	0.000 V & H, <i>p</i> = 0.000* V & O, <i>p</i> = 0.000* H & O, n.s.*
6 months	29	13	12	0.000 V & H, <i>p</i> = 0.000* V & O, <i>p</i> = 0.000* H & O, n.s.*
<i>SBSN</i>				
6 weeks	18	18	17	n.s.
6 months	14	11	9	n.s.
Incision scar length (mm)	4.1 ± 0.4	4.0 ± 0.6	3.8 ± 0.6	n.s.
Subjective sensory loss at 6 months: no. (%)	16 (42.1)	8 (21.6)	5 (13.5)	0.011 V & H, <i>p</i> = 0.057* V & O, <i>p</i> = 0.006* H & O, n.s.*
Subjective score at 6 months (mean)	5.6 (3–8)	6.4 (4–9)	6.6 (4–9)	n.s.

\* V vertical incision group,  
H horizontal incision group,  
O oblique incision group

At 6 months, 22 % (25/112) of patients had subjective complain of sensory loss, highest (12, 32 %) in the vertical incision group and lowest (5, 13.5 %) in the oblique incision group. Out of these, only 9 patients (8 %), who deemed their nerve injury to be significant in their daily activities, had paraesthesia or numbness affecting either the IPBSN alone (4/7) or both the IPBSN and SBSN (5/7) but not the SBSN alone. Sanders et al. [20] reported 8.8 % patients with IPBSN with or without SBSN injury had irritating hypesthesia affecting activities of daily living, whereas isolated SBSN injury was never associated with the same. They proposed that non-irritating hypesthesia in the SBSN distribution is underreported by the patient and likely to be underrecognized by the physician unless specifically questioned.

The area of hypesthesia was noted to decrease significantly with time. The residual hypesthesia at 6 months was mostly around the incision only. The recovery pattern noted was from distal to proximal in direction, which may be explained by encroachment from surrounding sensory nerves.

The cause of injury to IPBSN is directly related to the incision. Vertical incision which is perpendicular to both the trunks of IPBSN places these branches at risk [24]. This may be the reason for highest rate of IPBSN injury seen with vertical incision. The horizontal incision is safer with less incidence of IPBSN injury, probably because it can cause damage to the inferior trunk of IPBSN only. With the oblique incision, the direction of incision is almost parallel to the IPBSN, and thus, the risk of IPBSN injury is the lowest.

Concern over the tendon stripper has been raised [14, 16, 18, 25] but rarely reported [2]. Sanders et al. [20], on the basis of injury patterns and anatomical data, concluded that SBSN injury occurs during passage of the tendon stripper despite placing the leg in the figure-four position. The SBSN courses posterior to the skin incision and the sartorial fascia and is thought to be translated even more posteriorly with the knee in flexion. Therefore, SBSN injury is not explained by the skin or fascia incision for graft harvest and placement.

**Table 3** Regression of area of hypaesthesia with time by group

		Vertical ( <i>n</i> = 38)	Horizontal ( <i>n</i> = 37)	Oblique ( <i>n</i> = 37)	<i>p</i> value	
Area of sensory loss (mean + SD) cm <sup>2</sup>	6 weeks	62.3 ± 32.2	38.6 ± 22.8	26.4 ± 22.6	<i>p</i> = 0.000 V & H, <i>p</i> = 0.003* V & O, <i>p</i> = 0.001* H & O, <i>p</i> = 0.044*	
		3 months	52.3 ± 28.8	26.9 ± 16.4	19.2 ± 12.4	<i>P</i> = 0.000 V & H, <i>p</i> = 0.001* V & O, <i>p</i> = 0.000* H & O, <i>p</i> = 0.021*
			6 months	44.6 ± 24.4	22.7 ± 14.3	14.4 ± 9.5

\* V vertical incision group,  
H horizontal incision group,  
O oblique incision group

Yosmaoglu et al. [28] observed that harvest of gracilis affects knee flexion isokinetic torque negatively at low angular velocity which could be important for functional activity or sports with high demands on hamstring muscle strength. They recommended preserving gracilis muscle during ACL reconstruction. Perhaps, preserving gracilis will also decrease incidence of SBSN injury significantly. Also in recent studies, outcome of ACL reconstruction with achilles tendon allograft has been shown to be comparable with autogenous hamstring tendons, with the added advantage of less graft harvest-related complications and better knee flexor strength [11, 17, 23].

The study has several limitations. The first was the observer bias. These data were collected by only one surgeon at one institution. The incision could also tip the patient about the study. The follow-up period was short. Additional methods, that is, an electrophysiological analysis and a knee walking test, would have been more useful.

Fortunately, the clinical ramifications of this event are usually low, and most injuries do not result in much disability. However, neurovascular injuries can have medicolegal implications. It is important to understand that SBSN injury may be an intrinsic problem associated with blind, mini-incision and distal-to-proximal harvest, and the patient should be informed regarding this event.

## Conclusions

Injury to the infrapatellar branch of saphenous nerve (IPBSN) often occurred during hamstring graft harvest. Vertical incision has maximum incidence of IPBSN injury and poorest subjective outcome. Oblique followed by transverse incision for hamstrings graft harvest minimizes the

incidence of injury to IPBSN. Sartorial branch of saphenous nerve (SBSN) injury was equally common in all the three incisions used. Area of cutaneous hypesthesia gradually reduces with time, and it may even go for full recovery. However, the sensory loss does not impair normal daily activities in most of these patients.

Use of an oblique incision for graft harvesting is recommended, and also the surgeon should explain this event as a possible complication to the patient.

**Conflict of interest** None.

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