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Sports Traumatology & Arthroscopy
DOI: 10.14744/start.2024.75397
Sports Traumatol Arthrosc 2024;1(1):43-48

Review

How to Avoid Iatrogenic Saphenous Nerve Injuries during Hamstring Tendon Harvesting: A Narrative Review

Izzet Bingol,[1] Aliekber Yapar,[2] Enejd Veizi,[1] Haci Ali Olcar,[3] Mehmet Faruk Catma,[4] Oguzhan Pekince,[5] Muhammet Baybars Ataoglu[6]

[1]Department of Orthopaedics and Traumatology, Ankara Yildirim Beyazit University, Ankara, Türkiye

[2]Department of Orthopedics and Traumatology, University of Health Sciences, Antalya Training and Research Hospital, Antalya, Türkiye

[3]Department of Orthopaedics and Traumatology, Yozgat Bozok University Faculty of Medicine, Yozgat, Türkiye

[4]Department of Orthopedics and Traumatology, University of Health Sciences, Ankara Etlik City Hospital, Ankara, Türkiye

[5]Department of Orthopedics and Traumatology, University of Health Sciences, Konya City Hospital, Konya, Türkiye

[6]Department of Orthopedics and Traumatology, Gazi University Faculty of Medicine, Ankara, Türkiye

Cite this article as:
Bingol I, Yapar A, Veizi E, Olcar HA, Catma MF, Pekince O, et al. How to Avoid Iatrogenic Saphenous Nerve Injuries during Hamstring Tendon Harvesting: A Narrative Review. Sports Traumatol Arthrosc 2024;1(1):43-48.

Address for correspondence:
Aliekber Yapar.
Department of Orthopedics and Traumatology, University of Health Sciences, Antalya Training and Research Hospital, Antalya, Türkiye
E-mail:
aliekberyapar@hotmail.com

Submitted: 04.07.2024
Revised: 23.10.2024
Accepted: 24.10.2024
Available Online: 28.11.2024

Sports Traumatology & Arthroscopy – Available online at www.stajournal.com

ABSTRACT

Anterior cruciate ligament (ACL) reconstruction commonly involves the use of hamstring tendon grafts, which are associated with a risk of saphenous nerve injury, particularly the infrapatellar branch. These injuries can lead to sensory disturbances, including numbness, dysesthesia, and chronic pain, significantly impacting patient outcomes. With the growing use of minimally invasive techniques, understanding how to avoid iatrogenic saphenous nerve injuries during tendon harvesting is critical for optimizing surgical success. This narrative review aims to summarize the current techniques for minimizing saphenous nerve injuries during hamstring tendon harvesting and provide practical recommendations based on existing literature. The review explores various surgical approaches, including different incision placements, tendon harvesting techniques, and innovative minimally invasive methods. Studies were selected based on their focus on reducing nerve injuries, with special emphasis on randomized controlled trials, technical notes, and case series. Techniques such as oblique and modified oblique incisions, posterior mini-incisions, and endoscopic harvesting have demonstrated reduced rates of saphenous nerve injury compared to traditional vertical or transverse incisions. Posterior and popliteal fossa approaches, in particular, showed a significant decrease in injury rates, while endoscopic harvesting further minimizes soft tissue damage. However, limitations include anatomical variability and the technical difficulty of some approaches. To minimize the risk of iatrogenic saphenous nerve injury during hamstring tendon harvesting, surgeons should consider using oblique or posterior incisions, opt for minimally invasive or endoscopic techniques when possible, and tailor their approach to the patient's anatomy. Further research into nerve mapping and long-term outcomes of these methods is needed to refine current practices.

Keywords: ACL reconstruction, hamstring tendon harvesting, iatrogenic injury, nerve protection, saphenous nerve injury

INTRODUCTION

The use of hamstring tendons (HT) as grafts in anterior cruciate ligament (ACL) reconstruction is a well-established and widely accepted surgical technique [1]. However, harvesting HT is not without complications, particularly concerning the saphenous nerve (SN). Iatrogenic injury to the SN, especially its distal branches, including the infrapatellar (IPBSN) and sartorial (SBSN) branches, is common and often results in sensory disturbances, such as hypoesthesia, dysesthesia, and painful neuromas in the affected area [2-4]. These complications can significantly impact patient satisfaction and may even affect postoperative functional outcomes [5-7].

The SN, which runs parallel to the femoral vein and enters the adductor canal before dividing into the infrapatellar (IPBSN) and sartorial (SBSN) branches, is highly susceptible to damage during HT harvesting due to its close proximity to the surgical field [8-10]. Injury to these branches can result from various incision techniques and also instruments used in graft harvesting. Evidence indicates that vertical incisions carry a higher risk of SN injury compared to oblique or horizontal incisions [11,12]. Consequently, sensory disturbances following SN injury are common, with reported rates ranging from 12% to 88%, depending on the incision technique employed [3,11].

Over time, various technical modifications have been proposed to reduce the risk of iatrogenic saphenous nerve (SN) injuries. These modifications include smaller, oblique incisions, alternative incision locations, and minimally invasive endoscopic techniques aimed at preserving nerve integrity [5,12-14]. This review examines the current literature on methods to prevent SN injury during HT harvesting. By exploring these approaches, this review provides a comprehensive overview of the strategies developed to minimize complications associated with HT harvesting, ultimately enhancing postoperative outcomes in anterior cruciate ligament reconstruction (ACLR).

Anatomy of the Saphenous Nerve

Description of the Nerve's Course

The SN represents the longest purely sensory branch of the femoral nerve (Fig. 1). It has its origin in the femoral triangle and runs in close proximity to the femoral artery within the adductor canal before diverging distally [15,16]. The saphenous nerve, which emerges from the adductor canal, subsequently divides into two principal branches: the SBSN and the IPBSN. The IPBSN typically traverses medially, running superficial to the sartorius muscle, and courses down the medial aspect of the knee. It provides sensory innervation to the anteromedial aspect of the knee and the anteroinferior portion of the knee joint [17,18]. The IPBSN frequently crosses the patellar tendon in a transverse manner, with the trajectory depending on the presence of anatomical variability. In the medial aspect, the course is nearly vertical, whereas at the level of the patellar tendon, it is oblique [10,17]. The SBSN runs in a more posterior direction, descending alongside the sartorius muscle and gracilis tendon. It emerges subcutaneously in the vicinity of the medial malleolus and provides sensation to the medial aspect of the leg and foot [16,19,20].

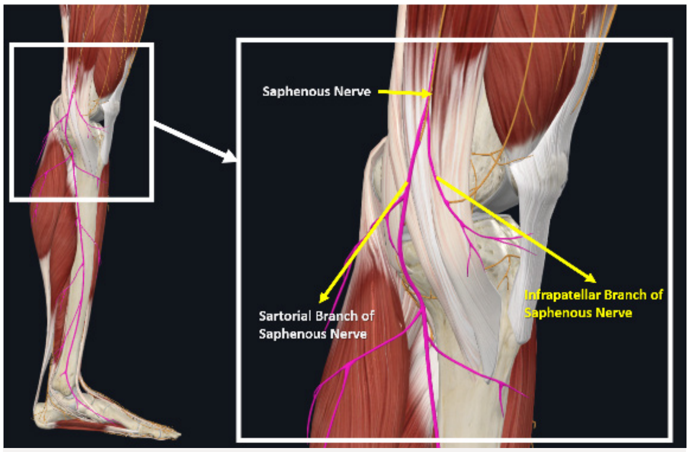

Figure 1. The anatomy of the saphenous nerve and its branches.

Vulnerable Zones

Several regions of the saphenous nerve and its branches are particularly vulnerable during surgical interventions involving HT harvesting. The IPBSN is at significant risk due to its proximity to the graft harvesting site. This branch typically pierces or courses along the sartorius muscle, and because of its superficial location near the medial knee, it is prone to injury during tendon stripping or incisions [17,20]. Anatomical studies indicate that the IPBSN is highly variable, with the nerve trunk located between 4 and 7 mm from the medial border of the patella [18,19]. The region where the SN exits the adductor canal and the sub-sartorial space, located just above the tibiofemoral joint line, is another vulnerable area. Injuries in this region often occur during blunt dissection or tendon strippers are used [20]. Cadaveric studies have demonstrated that gracilis tendon harvesting can lead to both incisional and non-incisional injuries, with non-incisional injuries affecting the sartorial branch as it descends posteriorly to the medial hamstring tendons [20]. Moreover, the course of the nerve varies significantly, making it challenging to define a "safe zone" during graft harvesting procedures [10]. As a conclusion, SN, particularly its IPBSN, is at high risk for iatrogenic injury during HT harvesting due to its anatomical course along the medial aspect of the knee. Knowledge of the nerve's trajectory and its anatomical variability is essential for surgeons to minimize the risk of sensory disturbances.

Clinical Presentation following SN injury

Injury to the SN can lead to several clinical manifestations, ranging from mild sensory disturbances to debilitating neuropathic pain. The most common symptom following a saphenous nerve injury is numbness or hypoesthesia along the medial aspect of the knee and leg. Patients typically describe a "dead" or "numb" feeling in the affected area, with diminished sensitivity to touch [3,4]. This sensory loss may extend to the medial lower leg, depending on the extent of the injury. In some cases, patients may experience sharp, shooting pains in the distribution of the injured nerve. Neuropathic pain can be persistent and may be exacerbated by movement or touch, making it a significant source of postoperative discomfort [12]. Dysesthesia, or abnormal sensations, such as tingling or burning, is another common symptom. Some patients may develop allodynia, where even light touch causes significant pain [21]. These symptoms can interfere with daily activities and affect the patient's overall quality of life. Rarely, injury to the nerve can lead to the formation of neuromas, which are painful nerve growths. Neuromas are particularly troublesome, as they often result in chronic pain and may require additional interventions such as nerve block injections or even surgical excision [3]. Patients with significant saphenous nerve injuries often report prolonged recovery periods, with persistent sensory deficits lasting months or even years after surgery. In some cases, these symptoms may be permanent [4,12]. A recent study has demonstrated that patients with SN injury have a higher incidence of re-rupture compared to those without [7].

Preventative Techniques

Minimizing trauma to the saphenous nerve (SN) during tendon harvesting requires careful attention to surgical technique. Several approaches have been developed to mitigate the risk of nerve injury (Table 1).

Incision Placement

Optimal incision placement is essential to reduce the risk of SN injury during hamstring tendon (HT) harvesting. Various incision types—including vertical, oblique, popliteal, and transverse—have been evaluated for their impact on the infrapatellar branch of the saphenous nerve (IPBSN) and other branches. Studies have consistently demonstrated that oblique incisions are superior to vertical and transverse incisions in reducing nerve damage risk [6,9,11,12,22]. Zhu et al. [12] compared a modified oblique incision with the classic oblique incision, showing a significant reduction in IPBSN injuries (9.4% vs. 33.3%). Oblique incisions are recommended due to their alignment with Langer's lines, which minimizes sensory disturbances [12,22]. Additional techniques, such as the posterior mini-incision in the popliteal fossa, described by Kodkani et al. and Prodromos et al., have been successful in avoiding SN injury altogether [2,14]. In a prospective randomized trial, Franz and Baumann found that a popliteal fossa incision led to no nerve injuries, while a conventional anteromedial incision had a 14% injury rate [8]. Similarly, García Hernández et al. [21] reported only a 2% incidence of sensory complications with the posterior approach, compared to 16% with the anterior approach.

Table 1. Hamstring tendon harvesting techniques that might decrease iatrogenic SN injuries

Author	Year	Study design	Technique	SN injury
Kodkani et al. [2]	2004	Technical note	Posteromedial incision	Not reported
Prodromos et al. [14]	2005	Case series (n=175)	Popliteal incision	%0
Mirzatolooei and Pisoodeh [3]	2012	Prospective comparison (n=98)	Surgical exploration and detection of the SN branches	20.5% versus 72%
de Padua et al. [4]	2015	Retrospective comparison (n=110)	Single ST tendon harvesting vs. ST & GT harvesting	36.1% vs. 58.1%
Franz and Baumann [8]	2016	Randomized clinical trial (n=100)	Popliteal fossa incision vs. Classical anteromedial oblique incision	0% versus 14%
Colombet and Graveleau [5]	2016	Technical note	Endoscopic	Not reported
Yeh et al. [13]	2018	Technical note	Endoscopic	Not reported
Zhu et al. [12]	2021	Randomized clinical trial (n=62)	Posterior modified oblique incision vs. Classical anteromedial oblique incision	9.4% vs. 33.3%
García Hernández et al. [21]	2022	Retrospective comparison (n=100)	Popliteal fossa incision vs. Classical anteromedial oblique incision	2% vs. 16%

Tendon Harvesting Techniques

Minimally invasive techniques, such as the anterior semitendinosus harvest described by Colombet and Graveleau, aim to reduce incision size and limit soft tissue disruption [5]. This approach uses a 2 cm incision with precise tendon identification, decreasing the likelihood of inadvertent nerve injury [5]. Yeh et al. [13] introduced an endoscopic harvesting technique that requires a smaller incision (1-1.5 cm) and provides better visualization, allowing for safer dissection of fascial bands and accessory tendons. This technique enables clear identification of the gracilis and semitendinosus tendons, reducing the risk of SN injury by maintaining a controlled and well-visualized dissection. Direct visualization of the saphenous nerve branches may be advantageous for cases with a particularly high risk of nerve injury. Mirzatolooei and Pisoodeh [3] demonstrated that by exploring and protecting sensory branches of the SN during harvesting, the rate of postoperative sensory loss was reduced from 72% to 20.5%. By carefully selecting incision sites and employing advanced harvesting techniques, surgeons can significantly decrease the risk of iatrogenic SN injuries during HT harvesting.

DISCUSSION

The findings from this review highlight several techniques designed to reduce the incidence of SN injuries during HT harvesting. The effectiveness of oblique incisions in reducing IPBSN injuries has been consistently demonstrated. Zhu et al. [12] reported that a modified oblique incision significantly lowered the risk of IPBSN injury compared to the classic oblique incision (9.4% vs. 33.3%). Similarly, Mirzatolooei and Pisoodeh found that direct visualization and preservation of saphenous nerve branches during surgery reduced postoperative sensory deficits from 72% to 20.5% [3]. Posterior incision techniques, such as those proposed by Kodkani et al. [2] and Prodromos et al. [14], showed promising results in reducing nerve injuries. Franz and Baumann found that harvesting the hamstring tendon via a popliteal fossa incision eliminated nerve injuries compared to the conventional anteromedial approach (0% vs. 14%) [8]. These findings align with García Hernández et al. [21], who reported a lower rate of neurological complications (2%) with the posterior approach. However, evidence remains scarce on the long-term sensory outcomes of some techniques, particularly minimally invasive and endoscopic harvesting approaches. While studies such as those by Colombet and Graveleau [5] and Yeh et al. [13] have introduced innovative methods with smaller incisions, the long-term sensory outcomes of these techniques have not been fully explored.

Although several harvesting techniques have been developed to reduce SN injury, each has limitations. The primary limitation of posterior and minimally invasive approaches is the risk of a shorter tendon harvest. Franz and Baumann found that while the posterior approach reduced nerve injuries, it also resulted in a slightly shorter tendon length (272 mm vs. 292 mm with the anteromedial approach), which may affect graft strength and sufficiency for fixation [8]. Similarly, Yeh et al. [13] noted that the endoscopic technique, while reducing incision size, requires advanced skills and specialized equipment, potentially limiting its widespread adoption. Another limitation is the SN's anatomical variability. Even with meticulous surgical techniques, variations in nerve anatomy may increase the likelihood of nerve injury.

Future studies should focus on refining existing techniques and exploring novel approaches to reduce the incidence of SN injuries further. Potential research areas might include refinement of endoscopic graft harvesting, nerve mapping technologies, and comparative studies on different techniques. In the future, endoscopic hamstring tendon harvesting can replace traditional open surgical techniques. Integrating intraoperative nerve monitoring or mapping technologies could provide surgeons with real-time feedback, helping them avoid nerve injury during tendon harvesting. Large-scale, multi-center trials comparing the sensory outcomes of posterior, oblique, and endoscopic approaches over extended follow-up periods are needed to confirm which method offers the best balance between tendon harvest quality and nerve safety.

CONCLUSIONS AND CLINICAL RECOMMENDATIONS

Preventing iatrogenic SN injuries during HT harvesting remains critical in anterior cruciate ligament (ACL) reconstruction. Various techniques, such as modified oblique incisions, posterior approaches, and endoscopic harvesting, have shown promise in reducing the incidence of nerve injuries. Studies comparing incision types and surgical methods have consistently found that posterior and minimally invasive techniques result in fewer nerve injuries than traditional anteromedial approaches. However, challenges such as tendon shortening and anatomical variability remain. Based on the findings of this review, the following practical recommendations are suggested for surgeons to minimize the risk of saphenous nerve injuries. To minimize the risk of nerve injury during hamstring tendon harvesting, surgeons should prioritize specific strategies to improve patient outcomes. An oblique or posterior incision is recommended whenever feasible, as these approaches have been demonstrated to reduce the likelihood of nerve injury. Additionally, minimizing incision size by considering minimally invasive or endoscopic techniques can further decrease soft tissue trauma and nerve damage. Although these techniques require advanced training and specialized equipment, their benefits in reducing complications are notable. In cases with a heightened risk of nerve injury, it is advisable to visualize and preserve saphenous nerve branches intraoperatively. By carefully exploring and identifying these branches, surgeons can help prevent postoperative sensory loss in patients. Furthermore, as the anatomy of the saphenous nerve can vary significantly, tailoring surgical techniques to each patient's unique anatomical structure is essential. Thorough preoperative planning should include a detailed assessment of individual anatomical variations, enabling adjustments in the approach as necessary.

DECLARATIONS

Acknowledgments: Turkish Sports Traumatology Arthroscopy and Knee Surgery Society, ACL Study Group members prepared this narrative review. The authors would like to express their gratitude to all contributors for their valuable input and expertise throughout the development of this review.

Ethics Committee Aproval: Not applicable.

Author Contributions: Idea/Concept – IB, AY, EV; Design – HAO, FC, OP, MBA; Control/Supervision – IB, MBA, AY; Data Collection and/or Processing – FC, OP; Analysis and/or Interpretation – AY, HAO; Literature review – IB, EV, MBA; Writing – IB, AY, EV, OP; Critical Review – IB, MBA, FC; References and fundings – AY, OP, EV; Materials – HAO, FC.

Data Avaliability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Conflict of Interest: The authors declared that they have no competing interests.

Informed Consent: Not applicable.

Use of AI for Writing Assistance: The authors declared that they had not used any type of generative artificial intelligence for the writing of this manuscript, nor for the creation of images, graphics, tables, or their corresponding captions.

Financial Disclosure: The author declares that they have no relevant or material financial interests that relate to the research described in this paper.

Funding Disclosure: No specific funding was received to prepare this manuscript.

Peer-review: Externally peer-reviewed.

ABBREVIATIONS

ACL: Anterior Cruciate Ligament

COI: Classic Oblique Incision

MOI: Modified Oblique Incision

IPBSN: Infrapatellar Branch of the Saphenous Nerve

SN: Saphenous Nerve

HT: Hamstring Tendon

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