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장딴지 신경이식술 후 공여부 합병증에 대한 연구

장정우[1] · 최승석[1] · 이장현[1] · 안희창[1] · 강낙헌[2]

한양대학교 의과대학 성형외과학교실[1], 충남대학교 의과대학 성형외과학교실[2]

Donor Site Morbidity after Sural Nerve Harvesting for Peripheral Nerve Reconstruction

Jung Woo Chang, M.D.[1], M. Seung Suk Choi, M.D.[1], Jang Hyun Lee, M.D., Ph.D.[1], Hee Chang Ahn, M.D., Ph.D.[1], Nak Heon Kang, M.D., Ph.D.[2]

[1]Department of Plastic & Reconstructive Surgery, College of Medicine, Hanyang University, Seoul; [2]Department of Plastic & Reconstructive Surgery, College of Medicine, Chungnam National University, Daejon, Korea

Purpose: Although the sural nerve is the most commonly used donor for autologous nerve graft, its morbidity after harvesting is sparsely investigated. The sural nerve being a sensory nerve, complications such as sensory changes in its area and neuroma can be expected. This study was designed to evaluate the donor site morbidity after sural nerve harvesting.

Methods: Among the 13 cases, who underwent sural nerve harvesting between January 2004 and August 2009, 11 patients with proper follow up were included in the study. The collected data included harvested graft length, actual length of the grafted nerve, anesthetic and paresthetic area, presence of Tinel sign and symptomatic neuroma, and scar quality.

Results: In 7 patients, no anesthetic area could be detected. Of the patients with a follow up period of more than 2 years, all the patients showed no anesthetic area except two cases who had a very small area of sensory deficit (225 mm^2) on the lateral heel area, and large deficit (4,500 mm^2) on the lateral foot aspect. The patients with a short follow up period (1~2 m) demonstrated a large anesthetic skin area (6.760 mm^2, 12,500 mm^2). Only one patient had a Tinel sign. This patient also showed a subcutaneous neuroma, which was visible, but did not complain of discomfort during daily activities. One patient had a hypertrophic scar in the retromalleolar area, whereas the two other scars on the calf were invisible.

Conclusion: After a period of 2 years the size of anesthetic skin in the lateral retromalleolar area is nearly zero. It is hypothesized that the size of sensory skin deficit may be large immediately after the operation. This area decreases over time so that after 2 years the patient does not feel any discomfort from nerve harvesting.

Key Words: Sural nerve graft, Donor site morbidity

I. INTRODUCTION

In the reconstruction of peripheral nerve defects, the use of autologous nerve grafts is the gold standard. Among many available nerves, which can serve as donors, such as the medial and lateral antebrachial cutaneous nerve, the superficial branch of the radial nerve, sensory branches of C4, the great auricular nerve, the terminal portion of the posterior interosseous nerve, the saphenous nerve and the lateral femoral cutaneous nerve, the sural nerve is most frequently used due to its generous length, ideal caliber for free nerve grafting, expendability, and low morbidity. There is a large quantity of literature dealing with the anatomy of the sural nerve, harvesting technique, and clinical outcome of nerve reconstruction using the sural nerve.[1-3] But investigations about the morbidity after sural nerve harvesting are very rare. This study was designed to quantitatively evaluate the donor site morbidity, especially sensory deficit after sural nerve harvesting and to provide a mapping of the deficit area. Sensory changes in its distribution area and symptomatic neuroma were investigated.

A. Anatomy

What is generally termed the "sural nerve" is exactly spoken the common sural nerve. According to Coert and Dellon the common sural nerve arises after communication of the medial sural nerve and the lateral sural nerve in the distal third of the leg in 84% (Fig. 1).[1] In these

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Address Correspondence : Seung Suk Choi, M.D., Department of Plastic and Reconstructive Surgery, Hanyang University Guri Hospital, 249-1 Gyomun-dong, Guri, Gyunggi 471-701, Korea. Tel: 031) 560-2330/Fax: 031) 560-2338/E-mail: msschoi@hanyang.ac.kr

cases the lateral cutaneous nerve of the leg derives from the lateral sural nerve. The medial sural nerve is a branch of the tibial nerve, whereas the lateral sural nerve derives from the common peroneal nerve. The common sural nerve arises proximal in the popliteal fossa in 12% of cases. In these legs the common sural nerve extends all the way down to the ankle, and the lateral cutaneous nerve of the leg arises from the common peroneal nerve. In 4% of cases no union occurs between the medial and lateral sural nerves. According to their study the lateral sural nerve may be absent in 4.6%, while other investigators found patterns varying from 16~36%.[2,3] The medial sural nerve is present in all legs.[1-3] The skin area innervated by the sural nerve is a vertical strip at the dorsolateral aspect of the calf and the lateral margin of the foot.

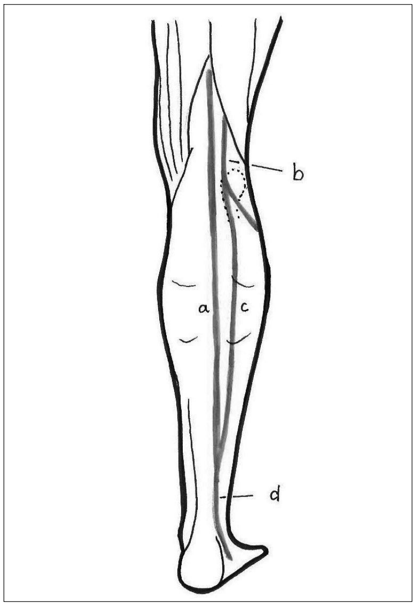

Fig. 1. Schematic drawing of the most common form (84% according to Coert and Dellon) of the anatomy of the sural nerve. The medial sural nerve (a) arises from the tibial nerve. The common peroneal nerve (b) gives off the lateral sural nerve (c), which unites in the distal third of the leg to form the common sural nerve (d).

II. MATERIALS AND METHODS

A. Patients

From January 2004 to August 2009, thirteen patients underwent sural nerve harvesting for the reconstruction of peripheral nerve defects at the Department of Plastic and Reconstructive Surgery, Hanyang University Guri Hospital, Korea. Of these patients eleven cases with a proper follow up were included in this retrospective study. All the nerve defects had resulted from trauma. The reconstructed sites were six digital

Table I. Patient Summary

Patient number	Sex / Age	f / u period	Recipient nerve	Harvested / Grafted nerve length	Sensory change	Symptomatic neuroma	Hypertrophic scar
1	M / 45	6y 1 m	Digital	8 cm / 3 × 2 cm	H (20 × 15 mm)	-	-
2	M / 28	5 y	Facial	5 cm / 3 cm	H (15 × 15 mm)	-	-
3	M / 26	5 y 8 m	Facial	6 cm / 2 × 2 cm	H (35 × 25 mm)	-	-
4	F / 47	4 y 11 m	Radial	14 cm / 2 × 6 cm	H (30 × 20 mm)	-	-
5	M / 24	4 y 2 m	Med. plantar	14 cm / 4 cm	A (130 × 70 mm)	-	-
6	M / 44	3 y 9 m	Digital	5 cm / 2 cm	A (15 × 15 mm)	-	-
7	F / 32	3 y 2 m	Digital	5 cm / 3 cm	H (20 × 15 mm)	-	-
8	M / 47	3 y 1 m	Digital	10 cm / 3 × 2 cm	H (35 × 20 mm)	-	-
9	M / 39	2 y 4 m	Ulnar	33 cm / 3 × 10 cm	P (100 × 30 mm)	-	+
10	M / 53	2 m	Digital	14 cm / 3.5 cm	A (208 × 65 mm)	+	-
11	M / 45	1 m	Digital	15 cm / 3 × 2 cm	A (130 × 80 mm)	-	-
Average	/39.1	3 y 6 m		11.7 cm / 7.2 cm			

M, male; F, female; y, year[s]; m, month[s]; H, hypesthesia: reduced sensory function; A, anesthesia: numbness; P, paresthesia.

nerves, two frontal branch of the facial nerve, one radial nerve, one medial plantar nerve, and one ulnar nerve. Nine patients were male and two were female (Table I).

B. Technique of nerve harvesting

All operations were performed in general anesthesia with the patient in supine position. After a longitudinal incision of about 6 cm between the lateral malleolus and the Achilles tendon, the sural nerve was dissected in the subcutis. The lesser saphenous vein, which is usually found superficial to the nerve was resected after ligation, if necessary. If the needed segment was less than 6 cm, the sural nerve was carefully harvested without further incision. As the needed nerve segment was longer than 6 cm in the majority of cases, one or more small additional, mostly horizontal incisions were placed more proximally (Fig. 2). Attention was paid to the anatomic communications between the medial and lateral sural nerves. When cutting the proximal end of the nerve, tension was applied in the distal direction, so that the remaining nerve stump could glide proximally, in order to be located away from the scar to avoid a painful neuroma.

C. Donor site evaluation after sural nerve harvesting

Graft data consisted of length of the harvested graft and actual length of nerve used for grafting. Donor site data included assessment of asensory and paresthetic area on the donor extremity, presence of Tinel sign and symptomatic neuroma, and scar quality (Table I). The area of sensory change at the lateral foot was assessed using Semmes-Weinstein monofilaments. The patient was asked to take a comfortable supine position in a quiet room. The investigated leg was held in slightly internal rotated position by a hard pillow. Mapping of the skin area with sensory change was performed using the 5.07 monofilament. Having his (or her) eyes closed the patient was asked to respond on perceptible touches with the monofilament, which was repeatedly applied moving along a radiant with the presumed center being in the posterior half of the lateral foot skin. The 5.07 monofilament was applied perpendicularly to the skin until the monofilament showed buckling. The borderline of sensed stimuli was marked, the points were connected similar to a contour line, and the area of sensory change was assessed by using a millimeter paper.

Evaluation of the presence of a painful neuroma was performed by eliciting a Tinel sign along the course of the nerve proximal to the donor site scar. A neuroma was considered painful, if the elicited Tinel sign was perceived as painful by the patient corresponding to an intensity of 5 on a visual analogue scale (VAS).

III. RESULTS

The harvested sural nerve graft was 11.7 cm long in average (5~33 cm) (Table I). The actual length of the grafted nerve was 7.2 cm in average (2~30 cm). All symptoms observed after sural nerve harvest were found on the lateral side of the foot according to its normal anatomical distribution.

Of the nine patients with a follow up period of more than 2 years seven (78%) did not have any anesthetic skin area (patients # 1, 2, 3, 4, 7, 8, 9). Most of these only

Fig. 2. Harvesting of the common sural nerve along with the lateral sural nerve through multiple incisions with the patient in supine position.

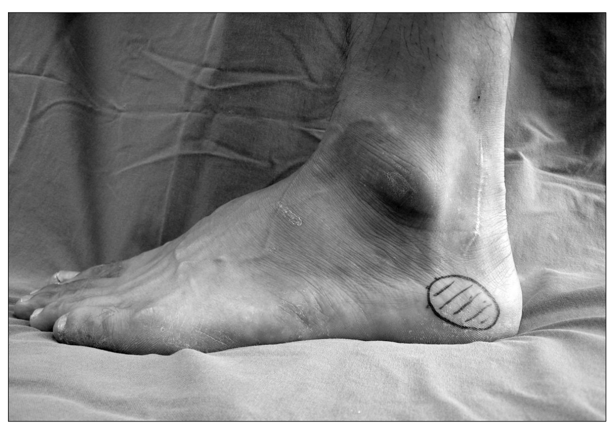

Fig. 3. Marking outlines the area of hypoesthesia. No anesthetic area was found in this patient (patient # 3). Note the inconspicuous donor site scar in lateral retromalleolar area.

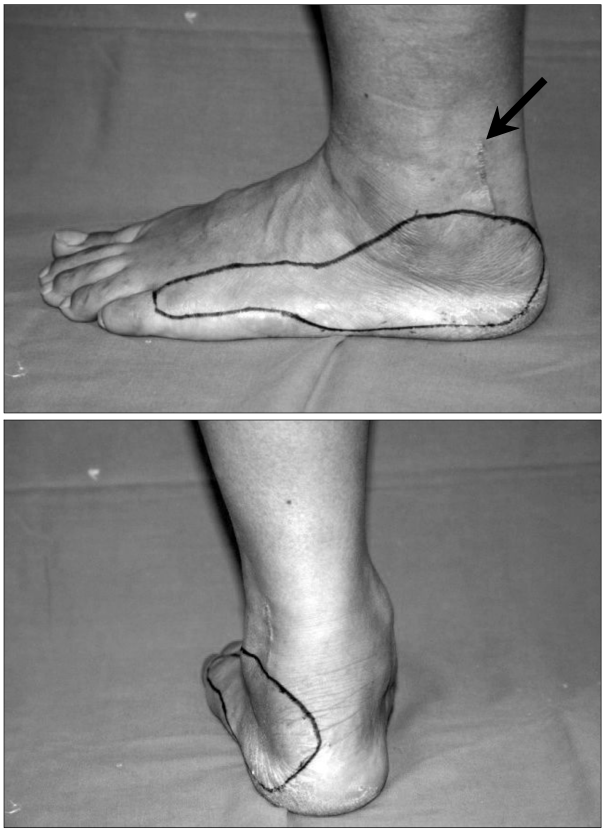

Fig. 4. Large area of anesthetic skin 2 m after sural nerve harvesting (patient #10). This patient had also a symptomatic neuroma proximal to the scar (marked with arrow), which was almost visible to the naked eye, but not painful.

complained of an small area with reduced sensory skin function (Fig. 3), and one patient had a skin area in the shape of a shallow semicircular band displaying slightly painful paresthesia on the lateral edge of the operated foot on touch, which did not have a negative impact on daily life (patients # 9). From the remaining 2 patients one had a very small area of sensory deficit (patient # 6: 225 mm^2) on the lateral heel area, whereas in one patient the area of deficit was rather large (patient # 5: 4,500 mm^2). The two patients with a short follow up period (1 month to 2 months) demonstrated a large anesthetic skin area (patients # 10, 11: 6,760 mm^2, 12,500 mm^2).

Only one patient had a Tinel sign on the distal end of the remaining sural nerve (patient # 10). This patient also showed a 15 × 10 mm sized subcutaneous neuroma, which was almost visible to the naked eye due to its superficial position and size (Fig. 4). The patient did not complain of discomfort due to this neuroma during daily activities. One patient had a hypertrophic scar in the retromalleolar area, whereas the two other scars on the calf of this same patient were inconspicuous (patient # 9).

Ⅳ. DISCUSSION

In search of alternatives for autologous nerve grafts, nerve allograft and nerve conduits composed of diverse materials are being intensively studied.[5-7] Although there are some promising results, the use of these nerve graft alternatives is still limited and their outcome is not comparable to those of autologous nerve grafts. Therefore the best way of reconstructing peripheral nerve defects currently is the use of autologous nerve grafts.

Of the many possible sources such as medial and lateral antebrachial cutaneous nerve, sensory branches of C4, great auricular nerve, terminal posterior interosseous nerve, and lateral femoral cutaneous nerve, the sural nerve is the most commonly used donor.[8] Although the sural nerve has been used as graft for decades, little is known about its morbidity. Most textbooks do not even mention the possible damage to the extremity, from which the sural nerve is taken.[8,9]

Mackinnon and Dellon state that the area of numbness diminishes with time.[10] This statement is supported by the results of our study, as they show that all patients with a follow up of more than 2 years (n = 9) had minimal to absent sensory deficit with the exception of one patient (patient # 5), who showed a rather large deficit skin area. In seven patients of this group (78%) the stimulus of the 5.01 Semmes-Weinstein monofilament was perceived on all of the foot skin. In contrast, the cases with a short observation period displayed a large anesthetic skin area (patients # 10, 11). The explanation for this phenomenon is that probably all patients experience a large deficit surface area immediately after denervation. This area, however, decreases over time, until it may even become non-existent. Several mechanisms for this recovery of sensory function may exist. Aszmann et al. hypothesized that recovery of sensation in denervated skin areas derived from two sources: regenerative sprouting form damaged axons at the site of the lesion and from collateral sprouting from adjacent nerves.[11] The neural plasticity of the brain is thought to be the third mechanism of sensory recovery after donor nerve transsection by Ehretsman et al.[12]

Patient # 5, the exception to the rule of long term sensory recovery after denervation, needs closer consideration, as this young male was a heavy smoker and showed poor compliance during investigation. Smoking may have counteracted with sensory recovery, and due to his non-compliance the mapping of anesthetic skin zone may not be reproducible in this case.

Tinel sign with radiation to the lateral edge of the affected foot was observed in one case. Although the patient did not complain of any limitations in daily life due to his symptomatic neuroma, much attention should be paid to the prevention of painful neuroma, when harvesting a sural nerve. When cutting the nerve this should be done under distally directed pulling of the graft, so that the remaining stump can glide proximally in order not to lie underneath the cutaneuous scar, where it could become adherent and thus symptomatic. Furthermore, if a long graft is harvested, the resection of the sural nerve should be carried out up to the popliteal fossa, so that the stump comes to lye below the deep fascia, where it is well protected against pressure.

The scars resulting from sural nerve harvesting are rather inconspicuous (Fig. 3). There was one case of hypertrophic scar in our series, which was a longitudinal scar located in the retromalleolar area. None of the proximal scars became hypertrophic. This observation may be misleading, as one might think that the distal location were the only factor favoring scar hypertrophy. The discerning factor controlling scar hypertrophy, however, is not only the distal location. It is the author's experience that longitudinal scars in the retromalleolar area have more tendency to become hypertrophic than transverse scars. Therefore using multiple small transverse incisions along the course of the sural nerve may improve the cosmetic outcome of the donor.

Our results are in accordance with previous work performed on donor morbidity after sural nerve harvesting concerning the improvement of sensory deficit over time.[11-13] Lapid et al. was the first group to quantitatively assess the sensory deficit after sural nerve harvesting in pediatric patients.[13] They evaluated the sensory thresholds on four predetermined points on the lateral foot of patients, who had undergone brachial plexus reconstruction with autologous sural nerve grafts, using Semmes- Weinstein monofilaments. 86% were found to show sensory deficit. But none of them reported clinical concerns regarding the sensation of their feet.

Mapping of the deficient skin has not been performed to date. In this paper the shape and the surface area of the sensory deficit were assessed quantitatively and mapped in adults. The results of this paper confirm that the sensory loss after sural nerve harvesting improves over time, as has been already pointed out by others. It may even disappear completely. Immediately after the operation the shape of the deficit was similar to that of a shoe (Fig. 4), which regressed to the shape of a small oval (Fig. 3), until it may disappear completely in the best case.

V. CONCLUSION

Our study on the morbidity after sural nerve harvesting shows that the initial area of sensory loss in the lateral retromalleolar area diminished after 2 years and it can be as small as zero. Even if a small area of anesthetic skin remained on the long term, it hardly caused any discomfort to the patients. Painful neuroma was also a rare finding after sural nerve grafting. Sural nerve harvesting did not cause cosmetic problems, as the scars after nerve retrieval were very inconspicuous, especially if multiple transverse incisions were used.

It can be summarized that sural nerve harvesting is a safe procedure with low donor site morbidity.

REFERENCES

1. Coert JH, Dellon AL: Clinical implications of the surgical anatomy of the sural nerve. *Plast Reconstr Surg* 94: 850, 1994
2. Ortiguela ME, Wood MB, Cahill DR: Anatomy of the sural nerve complex. *J Hand Surg Am* 12: 1119, 1987
3. WILLIAMS DD: A study of the human fibular communicating nerve. *Anat Rec* 120: 533, 1954
4. Netter FH: *Atlas of human anatomy*. 4th ed., Elsevier, 2006, p 540
5. Siemionow M, Sonmez E: Nerve allograft transplantation: a review. *J Reconstr Microsurg* 23: 511, 2007
6. Lohmeyer JA, Siemers F, Machens HG, Mailander P: The clinical use of artificial nerve conduits for digital nerve repair: a prospective cohort study and review of the literature. *J Reconstr Microsurg* 25: 55, 2009
7. Whitlock EL, Tuffaha SH, Luciano JP, Yan Y, Hunter DA, Magill CK, Moore AM, Tong AY, Mackinnon SE, Borschel GH: Processed allografts and type I collagen conduits for repair of peripheral nerve gaps. *Muscle Nerve* 39: 787, 2009
8. Slutsky DJ, Hentz VR: *Peripheral nerve surgery*. Churchill Livingstone, 2006, p 66
9. Shenaq SM, Kim JYS: Repair and grafting of peripheral nerve. In Mathes (ed) *Plastic Surgery*. 1th ed, Saunders, 2006, p 733
10. Mackinnon SE, Dellon AL: *Surgery of the peripheral nerve*. Thieme Medical, 1988, p 104
11. Aszmann OC, Muse V, Dellon AL: Evidence of in support

of collateral sprouting after sensory nerve resection. *Ann Plast Surg* 37: 520, 1996
12. Ehretsman RL, Novak CB, Mackinnon SE: Subjective recovery of nerve graft donor site. *Ann Plast Surg* 43: 606, 1999
13. Lapid O, Ho ES, Goia C, Clarke HM: Evaluation of the sensory deficit after sural nerve harvesting in pediatric patients. *Plast Reconstr Surg* 119: 670, 2007