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The functional results of acute nerve grafting in traumatic sciatic nerve injuries

Travmatik siyatik sinir yaralanmalarında uygulanan akut sinir greftlemesinin fonksiyonel sonuçları

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BACKGROUND

The sciatic and peroneal nerves are the most frequently injured in lower extremities, followed by tibial and femoral nerves. The aim of this study is to evaluate the functional results of acute nerve grafting in traumatic sciatic nerve injuries.

METHODS

A total of 9 patients with sciatic nerve defect were treated with primary nerve grafting. The mean age was 31.7 years. The etiologic factors were gunshot wounds, traffic accident, and penetrating trauma.

RESULTS

All of the patients had sciatic nerve defects ranging from 3.4 to 13.6 cm. The follow-up period ranged between 25 and 84 months. The tibial nerve motor function was "good" or "very good" (M3-M4) in 5 patients (55.6%). The plantar flexion was not sufficient for the rest of the patients. The peroneal nerve motor function was also "good" and "very good" in 3 patients (33.3%).

CONCLUSION

The functional results of the acute nerve grafting of the sciatic nerve within the first week after the injury are poorer than reported in the related literature. This protocol should only be applied to select patients who have adequate soft tissue coverage and healthy nerve endings.

Key Words: Acute nerve grafting; peripheral nerve injury; sciatic nerve.

AMAÇ

Siyatik ve peroneal sinirler alt ekstremitede en fazla yaralanan sinirler olup, bunları tibial ve femoral sinirler takip eder. Bu çalışmanın amacı travmatik siyatik sinir yaralanmalarında uygulanan akut sinir greftlemesinin fonksiyonel sonuçlarının değerlendirilmesidir.

GEREÇ VE YÖNTEM

Siyatik sinir defekti olan toplam 9 hasta primer sinir greftlemesi ile tedavi edildi. Hastaların ortalama yaşı 31,7'idi. Etyolojik faktörler ateşli silah yaralanmaları, trafik kazaları ve penetran yaralanmalardı.

BULGULAR

Hastaların tümünde 3,4 cm ile 13,6 cm arasında değişen siyatik sinir defektleri vardı. Hastaların takip süreleri 25 ile 84 ay arasında değişmekteydi. Tibial sinir motor fonksiyonu 5 hastada (%55,6) ''iyi'' ve ''çok iyi'' (M3-M4) olarak değerlendirilirken diğer hastalarda plantar fleksiyon yetersizdi. Peroneal sinir motor fonksiyonu ise 3 hastada (%33,3) ''iyi'' ve ''çok iyi'' olarak değerlendirildi.

SONUÇ

Siyatik sinir defektlerinde travma sonrasındaki bir haftalık dönemde uygulanan akut sinir greftlemesinin fonksiyonel sonuçları ilgili literatür ile kıyaslandığında daha düşüktür. Bu işlem yeterli yumuşak doku örtüsü bulunan ve sağlıklı sinir uçlarının belirlenebildiği seçilmiş hastalarda uygulanmalıdır.

Anahtar Sözcükler: Akut sinir greftlemesi; periferik sinir yaralanmaları; siyatik sinir.

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Lower extremity peripheral nerve injuries are less common compared to upper extremity injuries. The sciatic and peroneal nerves are the most frequently injured, followed by tibial and femoral nerves.[1,2] Intramuscular injections in the buttocks, hip fractures and hip surgery, contusions, penetrating trauma, and compression (priformis muscle entrapment or positional) at the buttock level are the most common causes of sciatic nerve injuries. Gunshot wounds, lacerations, penetrating trauma, femoral shaft fractures, contusion, compression, and iatrogenic injuries are the etiologic causes of many injuries at the thigh level.[3,4] Anatomically, the sciatic nerve is the longest and the largest diameter nerve of the body. It is composed of two different independent tibial and peroneal components.[5] These two nerves are covered with a common sheath at the thigh level, however there is no significant interfascicular communications during their courses. Each of these sciatic nerve components can be easily dissected separately for the surgical procedures such as nerve repair and grafting. The functional results and recovery after surgical interventions are not identical.[6,7] The peroneal division of the sciatic nerve is usually composed of one major bundle and located laterally to the tibial division. It is more susceptible to trauma. The peroneal nerve also has poor blood supply and less protective connective tissue compared to the tibial nerve. For these reasons, surgical treatment of the peroneal nerve is not as favorable as the tibial division.[5,6,8-11]

The nature of the trauma and the severity of the sciatic nerve damage are also important factors affecting the final outcome. Some traumatic causes of sciatic nerve injury, such as gunshot wounds and motor vehicle accidents, may result in nerve defects which require nerve grafting. The trauma to the surrounding tissues including vascular structures, soft tissue, and bone may also accompany the nerve injury. The functional results of the nerve grafting of sciatic nerve defects are poorer than primary repair at any level. Nerve grafting procedure can be used for nerve defect in the acute period (primary nerve grafting) or the late period (secondary nerve grafting). Secondary nerve grafting is usually advised for circumstances such as nerve defect caused by high energy trauma such as gunshot wounds or accompanying soft tissue defects. It is difficult to determine the extent of nerve damage and the presence of healthy ends for grafting in high energy trauma. However, regarding the literature there is no sufficient data regarding the functional results of acute sciatic nerve grafting.

The aim of this study is to evaluate the functional results of acute nerve grafting in traumatic sciatic nerve injuries.

MATERIALS AND METHODS

Between January 1999 and May 2007, nine patients with sciatic nerve defect caused by high energy trauma were treated with primary nerve grafting at the Department of Plastic Reconstructive and Aesthetic Surgery of Dokuz Eylul University Medical Faculty. Six patients were male (66.7%) and the others were female. The mean age was 31.7 years (ranged between 20 and 42 years). The etiologic factors were gunshot wounds (6 patients, 66,7%), traffic accident (2 patients, 22.2%), and penetrating trauma (1 patient, 11.1%). The injury was located at the upper third of the thigh (2 patients, 22.2%), middle third of the thigh (3 patients, 33.3%), and lower third of the thigh (4 patients, 44.5%).

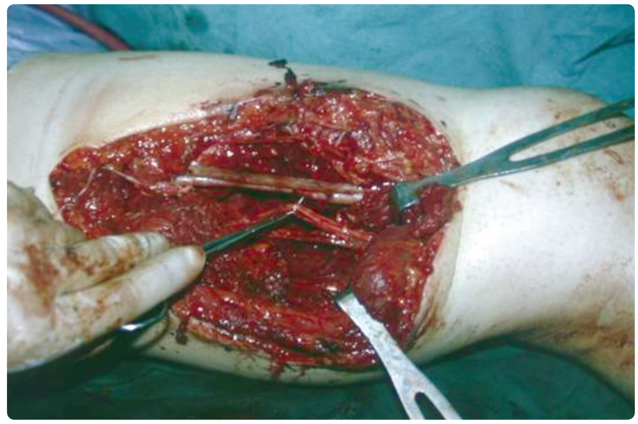

Fig. 1. Patient 7. 20-year-old female, gunshot injury at the middle third of the thigh. Intraoperative view of the patient. Anastomosis site of the vascular injury and 8 cm-long nerve graft are seen. Soft tissue defect was also reconstructed with local fasciocutaneous flap. Flap donor site was grafted.

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There was vascular trauma in 3 patients (33.3%) and soft tissue defect in 4 patients (44.4%), (Fig. 1). All of the patients had sciatic nerve defects ranging from 3.4 to 13.6 cm (average of 6.5 cm) and underwent acute nerve grafting procedure. The mean follow-up time was 47.9 months (ranging from 25 to 84 months). The demographic data of the patients including age, etiologic factors, localization, accompanying injuries, the length of the nerve graft, and follow-up time are shown in Table 1.

Patient management

Five patients were admitted to the emergency department just after the trauma while the rest of the patients were referred from the other centers for definitive surgery after emergency management within 7 days.

The neurological examination was performed including individual muscle strength and sensory examination. Electromyographical studies were not performed because the abnormal findings appear in target

Table 1. The demographic data of the patients including age, etiologic factors, localization, accompanying injuries, the length of the nerve graft, and follow-up time

Patient number	Age	Etiology	Localization in the thigh	Follow-up time (month)
1	33	Penetrating trauma	1/3 superior	84
2	37	Gunshot wound	1/3 inferior	66
3	29	Gunshot wound	1/3 inferior	62
4	42	Traffic accident	1/3 middle	43
5	40	Gunshot wound	1/3 inferior	40
6	32	Gunshot wound	1/3 superior	37
7	20	Gunshot wound	1/3 middle	35
8	28	Gunshot wound	1/3 inferior	39
9	25	Traffic accident	1/3 middle	25

muscles after 2-3 weeks.[12] There was a complete transection of the sciatic nerve in all patients and they were operated in the early period within the 7 days after the trauma. We also conducted postsurgical tests on all patients to determine the degree of recovered sensitivity and motor improvement. Muscle strength was evaluated using the British Medical Research Council (MRC) scale. The Semmes-Weinstein monofilament test was used for sensory evaluation (Table 2, 3). The motor and sensitivity improvements were graded on a five point scale. According to this scale; M5 and S1 were considered as excellent, M4 and S2 are very good, M3 and S3 are good but represent an improvement which is not enough for normal function. M0-M2 and S4-S5 were classified as inadequate.[13,14]

Surgical technique

Operations were performed under general anesthesia using an operating microscope (magnification x12). All of the patients had additional lacerations beside the sciatic nerve injury. In four patients (44.4%) extensive soft tissue defect was present requiring reconstructive procedures. In two patients (22.2%), additional incisions were used to define the extension of the injury and accompanying structures, whereas in the rest of the patients the existing lacerations were sufficient for exploration. As soon as the distal and proximal nerve stumps were determined, the tibial and common peroneal components of the sciatic nerve were dissected separately. Each nerve stump was examined under the operating microscope magnification. If there was suspicion regarding the normal anatomy and vascularization of the nerve, the nerve was resected to access the normal fascicular architecture, vascularization, and healthy epineurium. Final defect size was determined while the knee was in full extension. Then, the nerve grafting procedure was employed to repair the nerve defects. The sural nerve was used as a nerve graft in all patients. In three patients (33.3%), bilateral sural nerves were harvested to reconstruct longer nerve defects. In order to compansate retraction and shrinkage, nerve grafts 10 percent longer than the actual size of the defect were harvested.[15] In nerve grafting, grouped interfascicular technique with 9-0 and 10-0 nylon sutures was performed. The vascular injuries were also repaired in the same session. Interpositional vein grafting was used in 2 patients (22.2%) while end-to-end arterial repair was employed for one patient (Fig. 1). The soft tissue defects of the four patients (44.4%) were reconstructed with local fasciocutaneous flaps and skin grafts. During the postoperative period, the lower extremity was routinely immobilized for 7 to 15 days. After the immobilization period, patients underwent intensive physical therapy for a longer period of time.

The evaluation of patients in the postoperative period was based on serial clinical examination and electrodiagnostic studies. Each patient was followed-up at the 3rd week, 6th week, 3rd month, and 3-month intervals up to 24 months and at 6-month intervals thereafter.

Table 2. Classification of motor functions

Grade	Motor function
M0	Total paralysis
M1	Flicker
M2	Movement with gravity eliminated
M3	Movement against gravity (with no resistance)
M4	Movement against the gravity and resistance
M5	Full improvement

Table 3. Classification of sensation test groups

Grade	Sensation
S1	Normal
S2	Diminished light touch
S3	Diminished protective sensation
S4	Loss of protective sensation
S5	Not testable

RESULTS

There was no major complication in the early postoperative period. The revascularization of the extremities in three patients was also successful. Local wound infection was encountered in two patients (22.2%) which were treated with local wound care and systemic antibiotics. No revisional surgery was required in the early postoperative period. All of the local flaps and skin grafts used to reconstruct the soft tissue defects survived. Two patients (22.2%) were also operated on for secondary procedures such as scar revisions with excision and tissue expanders at the late postoperative period. Two patients (22.2%) underwent tibialis posterior tendon transfers for foot dorsiflexion at the third postoperative years after the trauma.

The follow-up period ranged between 25 and 84 months. The tibial nerve motor function (soleus and gastrocnemius muscle strength) was "very good" (M4) in 4 patients (44%) and "good" (M3) in 1 patients (11%). The plantar flexion was not sufficient for the rest of the patients. The peroneal nerve motor function (tibialis anterior muscle strength) was also "good" in 1 patient (11%) and "very good" in 2 patients (22%). (Fig. 2a-e) The postoperative results of the electrodiagnostic examinations were relevant with the physical examinations (Table 4).

The sensory recovery rate (Grade S2) was 44% (4 patients) and 22% (2 patients) for the tibial nerve and peroneal nerve respectively.

DISCUSSION

The primary goal of sciatic nerve repair is restoration of the protective sensibility of the sole. Secondary goals include restoration of the plantar flexion to achieve push-off during walking for tibial division and correction of drop foot for peroneal division.[16] The outcomes of recent studies of sciatic nerve repairs are more successful in comparison to the results of the large series previously published in the literature. During World War II, two studies were published on the sciatic nerve by Beebe-Woodhall and Sunderland including 1308 and 365 patients respectively. Their results were poor and disappointing.[6] Nowadays, improvement in microsurgical skills, techniques, and equipment (better magnification, fine instruments etc.), the use of longer nerve grafts, and results of neurobiological studies have also enabled better results following sciatic nerve repair.[17] Kim et al.[3] analyzed results of sciatic nerve repairs and reported that sharp lacerations undergoing primary end-to-end repair suture repair within 72 hours result in good outcomes at the buttock and thigh levels for both tibial and peroneal divisions as follows: buttock 73% and 30%, and thigh 93% and 69% for tibial and peroneal divisions, respectively. The results for nerve grafts repair at similar levels were: buttock 62% and 24%, and thigh 80% and 45%, respectively.Millesi reported the management of 39 patients with sciatic nerve

Fig. 2. **(a)** Patient 2. 37-year-old female, gunshot injury at the inferior third of the thigh. Postoperative 48th month view of the patient. Plantar flexion of the foot. **(b)** Patient 2. Dorsiflexion of the foot. **(c)** Patient 4. 42-year-old male, injury at the middle third of the thigh. Postoperative 34th month view of the patient. **(d)** Patient 4. Plantar flexion. **(e)** Patient 4. Dorsiflexion of the foot.

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Table 4. Concomitant soft tissue and vascular injuries, nerve graft length and functional recovery of the patients

Patient number	Vascular injury	Soft tissue defect	Nerve graft length (cm)	Tibial N. motor function	Peroneal N. motor function	Plantar sensory recovery
1	–	–	4.7	M4	M4	S2
2	–	–	5.6	M4	M3	S2
3	+	+	4.2	M2	M0	S4
4	–	–	3.4	M4	M4	S2
5	–	+	4.8	M4	M1	S2
6	+	–	7.8	M2	M0	S4
7	+	+	8.0	M2	M1	S4
8	–	+	13.6	M2	M0	S4
9	–	–	6.5	M3	M1	S3

injury. The results of cases requiring neurolysis and split repair was excellent, with 21 of 25 patients (84%) achieving good recovery. The nerve grafting results among 14 patients in the same study were less satisfactory, with only 7 of 14 patients (50%) achieving adequate recovery. After evaluation of the results, Millesi[16] also proposed simultaneous tendon transfer for patients with a significant nerve defects. According to their extensive experience with 380 sciatic nerve injuries, Kline et al.[4] stated that when nerve grafting was required, functional outcomes were poor rate 71% recovery for the tibial nerve and 32% for the peroneal nerve. They also recommended that secondary tendon transfers reserved in poor peroneal division recovery after 3-5 years of follow-up. Murovic et al.[18] have reported successful results for graft repair of tibial (62%) and peroneal (45%) nerves at thigh level.

The functional recovery rates of peroneal and tibial division are poorer in this study than those reported in the literature. This result may be caused by acute repair, but it should be also considered that the recovery rates of sciatic nerve grafting also depend on concomitant factors such as length of the graft, age of the patient and comorbidities at the repair sites.

There are few studies in the literature regarding the relationship between graft length and functional outcomes. There is no consensus on the critical length of the nerve graft affecting the final recovery rate. Several authors also propose a critical nerve graft length of 5 to 12 cm for good results.[19,20] Matejcik[13] reported that the best results were observed in grafts of up to 5 cm. Roganovic also suggested that the critical value for a successful outcome related to the length of the nerve defect was 5 cm.[21] Kim and Kline[20] reported good motor recovery with grafts shorter than 6 cm. Our patients had sciatic nerve defects ranging from 3.4 to 13.6 cm (average of 6.5 cm) and our results were similar to these studies. The patients with a nerve graft shorter than 6 cm had better results while those with a nerve graft of longer than 6 cm had poor motor and sensory recovery.

The age of patients may be important factor for nerve grafting and recovery. Taha and Taha[7] reported that good results were achieved for sciatic nerve injuries at any level among children. In our study, the mean age was 31.7 and we had no patients within the pediatric age group.

There are no precise data in the literature regarding the effects of comorbidities associated with the functional results of nerve repair. Matsuyama et al.[22] suggested that longer nerve grafts are usually associated with other factors such as more extensive and more proximal nerve injuries, corresponding with poorer functional results. Roganovic reported that associated comorbidities may affect the nerve repair outcome. Main artery lesion influences the results through ischemia, and bone fragments cause additional nerve trauma or subsequent callus spreads around the repaired nerve. Soft tissue defects frequently cause decreased muscle mass of the peroneal nerve effectors.[21] Major vascular injuries (3 patients, 33.3%) and extensive soft tissue defects (4 patients, 44.4%) were also encountered in our patients. The nerve injuries in these patients required longer grafts (>6 cm). The results among patients with no comorbidities include better functional outcomes. High energy traumas such as gun shot wounds may also cause associated soft tissue, bone and vascular injuries. Progressive necrosis of the nerve endings in this kind of trauma may compromise the identification of the healthy nerve ends. For these reasons acute nerve grafting should not be used for reconstruction after high energy traumas.

The timing of surgical repair of the sciatic nerve lesions is variable in the literature. A complete and severe loss of sciatic nerve function with no evidence of recovery during the first few months is generally accepted as indication for surgical repair.[4,20,23] The management of sciatic nerve injuries depends on loss of nerve continuity or lesion in continuity. If there is good vascularity and soft tissue coverage, sharp lacerations should be managed within a few days using the end-to-end technique.[10] Primary nerve repair has not been advocated in the literature for nerve lacerations with contusion and traction.[23,24] Some authors also suggested that a period of 2-4 weeks is necessary for distinct delineation of the injured nerve segments.[10,25,26] Extensive comorbidities (fractures, vascular injury, and loss of soft tissue coverage) are also reasons for delaying of the definitive nerve repair. We operated on all the patients within the acute period of the injury. Nerve grafting and repair of the associated injuries were completed in the same session for early functional recovery. Although there was improvement in all patients, functional recovery rates in the presented patient group are poorer than secondary nerve grafting procedures of the sciatic nerve that have been reported in the literature. It is important that sufficient soft tissue coverage is supplied and the healthy ends of the disrupted nerve must be identified for acute nerve grafting of the sciatic nerve.

In conclusion, the functional results of acute nerve grafting of the sciatic nerve within the first week after the injury were poorer than among the related literature. This protocol should only be applied among select patients who have adequate soft tissue coverage and healthy nerve endings after wound debridement.

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