

# Rehabilitation in a Patient with Replantation of Amputated Distal Leg

Alina TUDOSIE, MD<sup>a</sup>; Simona POPESCU, MD<sup>a</sup>; Delia CINTEZA, MD PhD<sup>a</sup>; Simona ROMANESCU, MD<sup>b</sup>; Roxana POPA, MD<sup>a</sup>; Alina SANDU, MD<sup>a</sup>; Andreea ROMILA, MD<sup>a</sup>; Ana Maria TINIUC, MD<sup>a</sup>; Raluca FLOREA, MD<sup>a</sup>

<sup>a</sup>National Institute of Rehabilitation, Physical Medicine and Balneoclimatology – the 4<sup>th</sup> Clinic

<sup>b</sup>Emergency Clinical Hospital “Floreasca” Bucharest – Plastic Surgery and Repairing Department

## ABSTRACT

**Background:** Many studies have been reported on replantation of an upper extremity after traumatic amputation, but there are only a few case reports on replantation of the lower extremities rather than amputation surgery. This is due to preoperative factors, complications and the possibility of good prosthetic substitution.

We describe here the dynamic evaluation necessary for a continuous rehabilitation treatment in a subject with replanted left foot after traumatic amputation.

**Case report:** A 58-year-old male person with amputation of the left leg at the level of the left talocrural joint, with talar dome and bimalleolar fractures and complete section of the blood vessels, nerves and tendons was considered for replantation surgery 7 hours after a traumatic injury.

For an accurate evaluation of the postoperative conditions over time, clinical functional assessment combined with imaging and neurophysiological examination were conducted.

Rehabilitation program is aimed to train the motor and sensory function of the replanted foot and to prevent undesired biomechanical changes that limit person's ability to perform everyday tasks. During the rehabilitation program there were a progressive recovery of the patient's protective sensation, active motion angles of the left ankle joint and muscle power of the replanted leg. Those are sufficient for walking activity and help the patient considerably in performing his everyday minimal housework.

**Conclusions:** A well designed postoperative dynamic rehabilitation program is necessary in order to regain functionality after successful distal leg replantation surgery. The clinical and imaging evaluation support a dynamic rehabilitation program adapted to different stages of functional recovery.

**Keywords:** leg replantation, rehabilitation, musculoskeletal ultrasound

Address for correspondence:

Delia Cinteza, Rehabilitation Medicine, Hospital INRMFB, 4<sup>th</sup> Clinic, 11A Ion Mihalache Blvd., District 1, Zip Code 79173, Bucharest, Romania  
e-mail: delcint@gmail.com

## INTRODUCTION

**A**lthough many studies have been reported on replantation of an upper extremity after traumatic amputation, there are only a few case reports on replantation of the lower extremities rather than amputation surgery. This is due to preoperative factors, complications and the possibility of good prosthetic substitution (1,2).

In this paper we present the ongoing progress and outcome of the rehabilitation treatment after replantation surgery in a person whose left foot was amputated at the level of the ankle by an electric saw. For an objective evaluation of the postoperative conditions over time, clinical and functional assessment combined with imaging and neurophysiological investigation are helpful. Adequate rehabilitation program prevents joint contracture, muscle weakness, joint instability and foot deformity and promotes injured nerve regeneration, with proved efficiency of the used rehabilitation techniques.

The rehabilitation program is important for a successful replantation to restore the function of the lower limb; it should be continued long term and adapted to different stages of functional recovery. □

## CASE REPORT

**A** 58-year-old male person was admitted to the Emergency Clinical Hospital Bucharest, on June 14<sup>th</sup> 2010, approximately 7 hours after a traumatic injury of the left leg amputated by the blade of an electric saw. The injury resulted in a clean, sharp laceration with disruption of the tendinous, vascular and neurologic structures. Amputation was produced at the level of the left talocrural joint, with talar dome fracture, bimalleolar fracture and complete section of the tendons, blood vessels and nerves. Only a small lateral skin bridge of approximately 7 cm remained intact - Figure 1.

Replantation surgery of the left leg was performed under general anesthesia with ischemic time lasting 9 hours up to the arterial anastomosis. Metallic osteosynthesis and suture of the blood vessels, nerves and tendons were performed.

He was referred to our Rehabilitation Medicine Department 3.5 months after the accident. For an accurate evaluation of the patient's



**FIGURE 1.** Amputated left leg before and after replantation surgery

status before and during the rehabilitation program, clinical functional assessment, imaging and neurophysiological evaluation were performed. □

## REHABILITATION PROGRAM

**D**uring the initial rehabilitative phase, the goals were: increasing pain-free range of motion (ROM), progressive muscle strengthening, proprioceptive training, sensory re-education, stimulation of nerve regeneration, prevention of deformity and stiffness.

For this patient we considered the following procedures and exercises:

- In order to increase pain-free ROM, passive and active exercises were indicated for ROM in all planes, as tolerated: dorsiflexion, plantar flexion, inversion, eversion, foot circles, alphabet.
- Progressive strengthening exercises include: isometric in a pain-free range; eccentric/concentric exercises and isoton-

ics (thera-band, heel and toe raises from sitting position with the foot in neutral position/inversion/eversion, then standing heel/toe raises), toe curls with a towel.

- Stretching gastrocnemius and soleus with increased intensity (Achilles stretch).
- Proprioceptive training for sensorimotor coordination, involving balancing exercises on Seated Biomechanical Ankle Platform System (BAPS board), wobble board training (initially sitting) and walk training.
- Active sensory training consisting of education, practice detecting, localizing and discriminating sensations and proprioceptive training.
- Electrotherapeutic modalities: electrical stimulation, biofeedback promoting injured nerve regeneration and maintaining a functional status of the denervated muscles and joints. Laser and ultrasound therapy shorten the time needed for correct lesion cicatrisation.

On the initial physical examination this person presented no inflammatory signs of the skin cicatrisation process after replantation surgery (Figure 2), no edema and no pain syndrome. He did not present any deformity of the foot.

The patient complained of cold intolerance - manifested as pain, discoloration (blue), numbness, stiffness of the toes and left leg, and behavior change (including the avoidance of cold and clothes protection against cold).

The patient presented protective sensory loss in the affected foot as the patient did not perceive any sensation of light touch (assessed with 5.07 Semmes-Weinstein monofilament test), pain, temperature, pressure and vibration. Distal proprioception was examined and he could not accurately locate toes position in space, except for hallux toe.

Total active motion angles of the left ankle joint were 5 degrees of dorsiflexion, the patient being able to walk with a cane, with partial weight-bearing (60%), for short periods of time (less than 5 minutes).

During the rehabilitation program, on physical examination, the ranges of motion of the ankle joint are shown in Table 1. Total active motion angles of the ankle joint were increased progressively over time from 5 to 20 degrees for dorsiflexion, 10 degrees being sufficient for walking activity.



FIGURE 2. Left leg - on initial physical examination, before the rehabilitation treatment

The muscle power of the replanted leg was measured before and during the rehabilitation program as shown in Table 1. Muscle power increased for active left foot dorsiflexion and for halux active extension 4 months after surgery. The active extension of toes 2-5 improved 5.5 months after the surgical replantation.

ROM-left foot				Muscle strength testing						
Dorsi flexion	Plantar flexion	Inversion	Eversion	Tibialis anterior	Extensor digitorum longus	Extensor hallucis longus	Peroneus	Calf muscles	Flexor digitorum longus	Flexor hallucis longus
5/20	0/0	0/0	0/0	MRC= 3-/4	MRC=1/3	MRC=2/3	MRC=0/0	MRC=2/3	MRC=0/0	MRC=0/0

**TABLE 1.** MRC=Medical Research Council scale for muscle strength testing (M 0-5). Values before and after the rehabilitation initial treatment

The patient progressed from partial to full weight-bearing using the cane to walking with a crutch with normal gait. The LEFS score was 24 points after 1 month of rehabilitation treatment, which is 30% of maximal function (compared to 11% before any rehabilitation treatment). This is functionally significant according to LEFS.

During the rehabilitation program, 6 months after the surgical replantation, the patient could perceive sensation of light touch, pain, temperature and also had the ability to locate body parts (toes) in space (proprioception).

Musculoskeletal ultrasound evaluation of the anterior ankle shows non-homogeneous, thickened tibialis anterior tendon with hypo-echoic zone. This corresponds to tendon su-

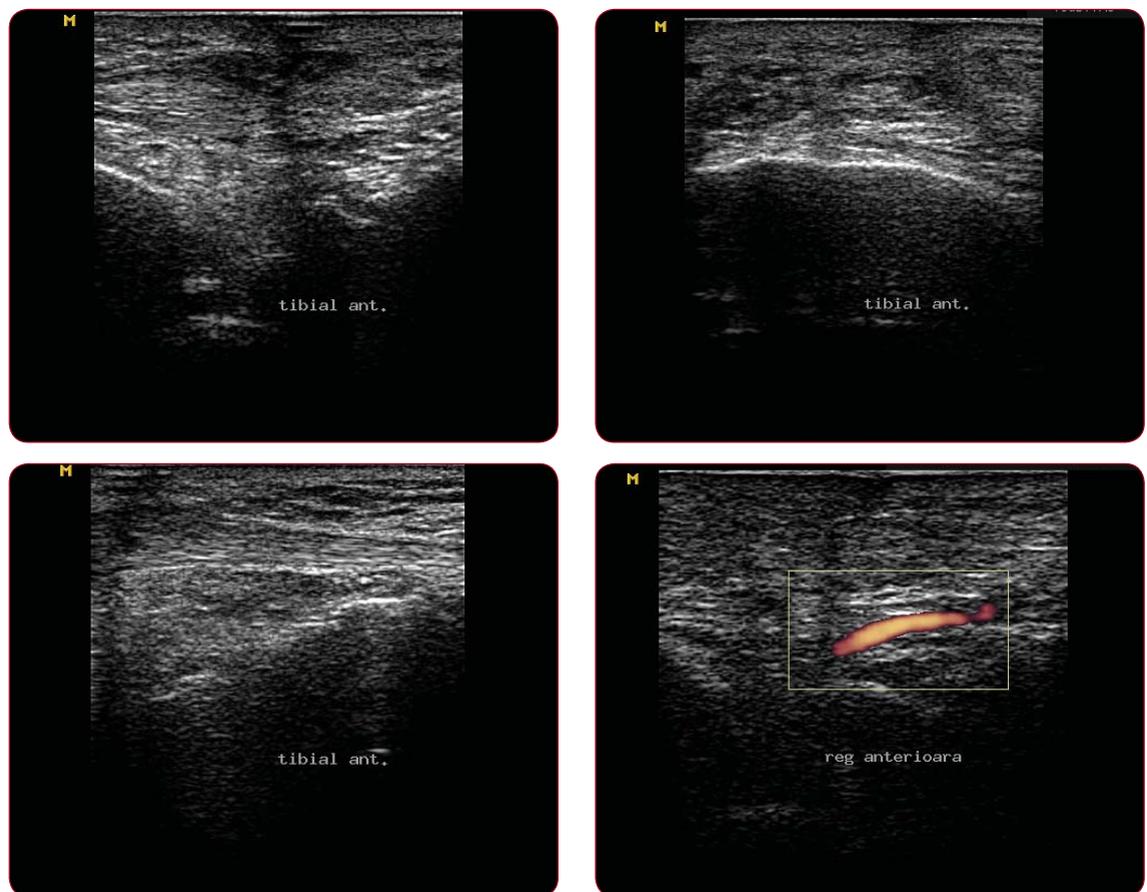
ture with continuous tendon fibers. Doppler examination indicates that the anterior tibial artery is continuous and permeable after arterial suture – Figure 3.

This is also showed for the Achilles tendon – Figure 4.

Medial retromalleolar region examination indicates that the tibialis posterior tendon has a different anatomical position after the surgical repair. Compared to the right side, this is situated at the proximal extremity of the medial malleolus and not behind it (Figure 5)

The continuity of the tibial nerve was also assessed by sonographic examination-Figure 6.

Antero-posterior and lateral view radiography show: metallic osteosynthesis of the medial malleolar fracture with new bone formation;



**FIGURE 3.** Anterior ankle – ultrasound evaluation



FIGURE 4. Posterior ankle - ultrasound evaluation

no displacement or alignment abnormalities were noticed; malunion of the lateral malleolar fracture; osteochondral fracture in the medial border of the talus with central sclerosis; decreased tibiotalar joint space with irregular articular bony margins-Figure 7.

The EMG examination of the left foot intrinsic muscles indicates the presence of spontaneous activity (fibs) that denotes denervation process-Figure 8.



FIGURE 5. Posteromedial ankle - ultrasound evaluation

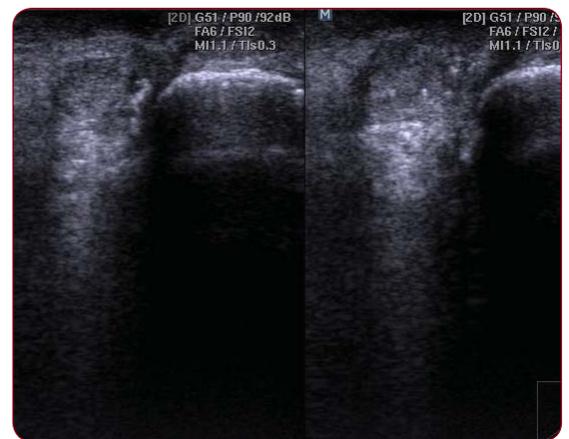


FIGURE 6. Posteromedial ankle – ultrasound evaluation of the tibial nerve

The presence of electrical activity in the left foot (with increased latency and lower amplitude compared to the right foot) reveals that sympathetic nervous fibers are continuous after tibial nerve suture – Figure 9. ■



FIGURE 7. Lateral and antero-posterior plain film of the left ankle

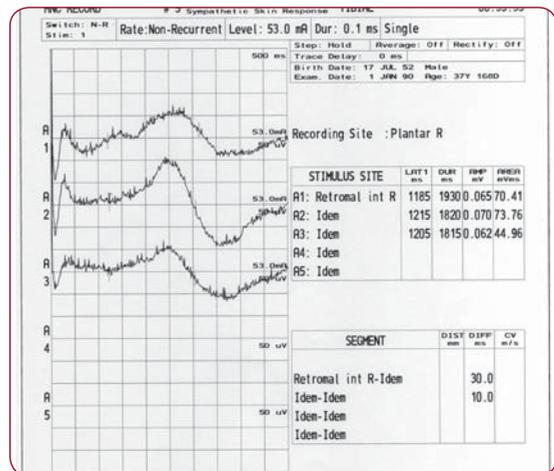
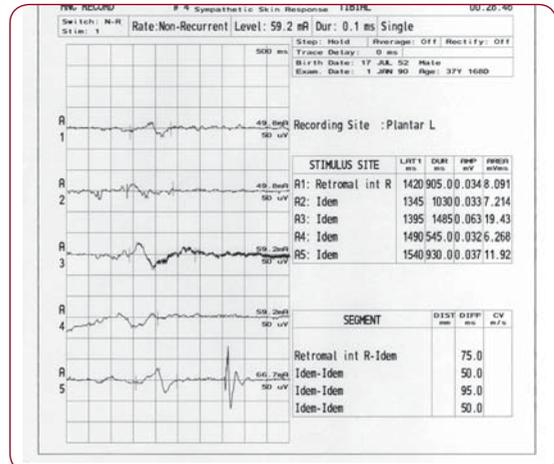


FIGURE 9. Sympathetic skin response test, 4 months after replantation surgery

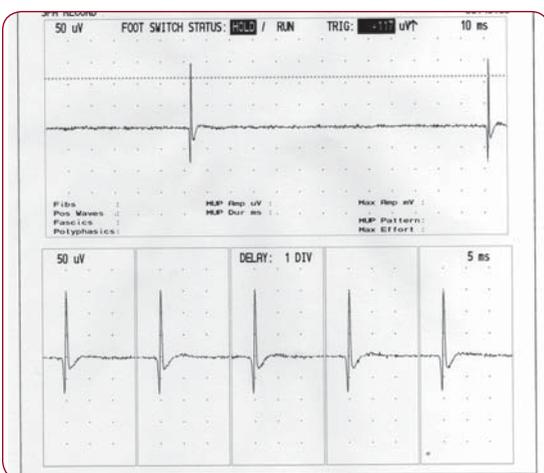
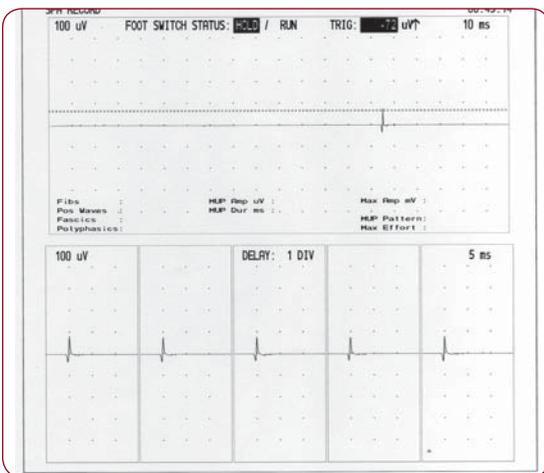


FIGURE 8. EMG examination of left foot - flexor hallucis brevis and extensor digitorum brevis, 4 months after replantation surgery

**DISCUSSION**

The neuromuscular status of the replanted distal leg was assessed by clinical and functional examination including the LEFS score, plain films, musculoskeletal ultrasound investigations, EMG, sympathetic skin response test (1,2). The following items were evaluated for this patient: pain, intolerance to cold, ankle joint range of motion, muscle power, sensory disturbance, foot deformity, condition of the sutured anatomical structures related to the clinical status and functional deficit. Until achieving good function of the replanted extremity, follow up is needed for adapting the rehabilitative treatment to the clinical status of the patient.

The status of the patient needs to be followed until clinical healing occurs and functional recovery is complete (1,2). Follow-up information included the results of the functional assessments — LEFS score (3) (Table 2). The LEFS was used as a measure of patients' initial

Activities	Extreme difficulty or unable to perform activity	Significant difficulty	Moderate difficulty	A little bit of difficulty	No difficulty
Any of your usual work, housework or school activities	0	1	2	3	4
Your usual hobbies, recreational or sport activities	0	1	2	3	4
Getting into/out of the bath	0	1	2	3	4
Walking between rooms	0	1	2	3	4
Putting on your shoes or socks	0	1	2	3	4
Squatting	0	1	2	3	4
Lifting an object, like a bag of groceries from the floor	0	1	2	3	4
Performing light activities around your home	0	1	2	3	4
Performing heavy activities around your home	0	1	2	3	4
Getting into/out of a car	0	1	2	3	4
Walking 200 m	0	1	2	3	4
Walking 1600 m	0	1	2	3	4
Going up or down 10 stairs	0	1	2	3	4
Standing for 1 hour	0	1	2	3	4
Sitting for 1 hour	0	1	2	3	4
Running on even ground	0	1	2	3	4
Running on uneven ground	0	1	2	3	4
Making sharp turns while running fast	0	1	2	3	4
Hopping	0	1	2	3	4
Rolling over in bed	0	1	2	3	4

TABLE 2. Lower extremity functional scale (LEFS)

function, ongoing progress and outcome as well as to set functional goals.

The improvement observed during the rehabilitation program is functionally significant for this patient.

Musculoskeletal ultrasound evaluates the morphologic changes, anatomy of the region and continuity of the blood flow after the replantation surgery. It has the advantage of allowing a dynamic assessment of the sutured tendons, tibial nerve and blood vessels during patient's follow-up.

Because of the lesion level reported to the nervous anatomical pathway, the electromyographic (EMG) testing of the intrinsic muscles of the left foot (flexor hallucis brevis and extensor digitorum brevis) is performed in order to examine the innervation status of the muscles of the replanted foot.

Plain films were used for fracture union evaluation, maintenance of the ankle mortise, and for the presence of post-traumatic ankle joint arthritis (4).

Post-traumatic cold intolerance, defined as abnormal pain with or without discoloration

(white/blue) and/or stiffness of the injured segment is a frequent and persistent sequela of the upper/lower extremity injury, especially when neurovascular structures are involved (5). This is due to the disturbance of the peripheral blood flow regulation mechanism in peripheral nerve injury patients. Recent studies support the case of a neural instead of an arterial origin of post-traumatic cold intolerance.

The tibial nerve supplies vasomotor nerve fibers to its cutaneous sensory territory. Vasomotor sympathetic nerve fibers join the sensory nerve fibers to the skin of the foot. After traumatic peripheral nerve injury there is disruption of the sympathetic signal with reduced thermal modulation capacities in the cold-sensitive replanted foot. This has therapeutic significance especially because there is no standard treatment available other than external protection of the injured segment to cold exposure by using protective clothing and pharmaceutical treatment aimed at improving peripheral vasodilatation.

Active vasodilatation returns after restoration of the sensory function. That is why recent studies show that cold intolerance is strongly correlated to the degree of sensory recovery.

Therefore, an important objective of our rehabilitation plan is the improvement of sensory recovery. During the rehabilitation program, 6 months after the surgical replantation, the patient could perceive sensation of light touch, pain, temperature as well as the ability to locate body parts (toes) in space (proprioception). At that time he did not complain of cold intolerance any longer (pain, discoloration (blue), numbness, stiffness of the toes and left leg), but change in behavior (avoidance of cold and clothes protection against cold) was still present.

This is consistent with the electro-diagnostic study performed for this patient 4 months after the injury. The autonomic nervous system is evaluated by the "sympathetic skin response" test (6). By measuring change in skin resistance following an electric stimulation, it provides an index of sweat production - that depends on the sympathetic skin innervation. The sympathetic skin response test indicates that sympathetic nervous fibers are continuous after tibial nerve suture (Figure 9).

Recent studies show that the damage resulting in decreased sensory awareness has a number of functional implications which can reduce an individual's ability to function independently and impact upon their quality of life (7,8). On the initial examination, the patient presented protective sensory loss in the affected foot as he did not perceive any sensation of light touch, pain, temperature and pressure. Distal proprioception was examined and he could accurately locate toes position in space only for hallux toe. 6 months after the surgical replantation, during the rehabilitation program, the patient could perceive sensation of light touch, pain, temperature as well as the ability to locate body parts (toes) in space (proprioception). □

### PARTICULARITY OF THE CASE

The muscle power of the replanted leg increased during the rehabilitation program for active dorsiflexion of the left foot, active extension of the halux and later, for the active

extension of the 2-5 toes. The patient could perform active plantar flexion, but the ankle range of movement for plantar flexion was absent because posttraumatic ankle joint arthritis limits the mobility of the left ankle. Still walking activity is possible.

Also, the lesion level justifies the possible active left foot dorsiflexion (M4) and halux extension (M3) and also active plantar flexion (M3), but it does not justify poor flexion and extension of toes 2-5 (M0/M1) that could be explained by the position and morphology changes after tendon suture, as showed by the ultrasound examination. Musculoskeletal ultrasound evaluation has the advantage over other imaging modalities in that it can trace the pathology proximally or distally in real time as required and allows a dynamic assessment. Moreover, later, at 6 months after the accident, toes extension improved with the rehabilitation program (M3).

The clinical absence of protective sensation 4 months after the replantation surgery and the presence of spontaneous activity that denotes denervation process at the level of the left foot intrinsic muscles on EMG examination suggest the possible need for internal and external neurectomy surgery. The above mentioned information was also confirmed by the results of the ultrasound examination of the posteromedial ankle.

Still, the regain of partial sensation of light touch, pain, temperature and pressure after 2 months of rehabilitative treatment indicates the importance of such program for the functional recovery. □

### CONCLUSIONS

We consider that rehabilitation treatment is of paramount importance in order to improve the functional impairment after foot replantation surgery. This involves a well designed postoperative dynamic rehabilitation program based on clinical long term follow-up and adapted to the clinical and functional status of the patient.

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