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Mini review article

SURGICAL TREATMENT OF FOOT DROP AFTER PERONEAL NERVE INJURY

HIRURŠKO LEČENJE PADA STOPALA NAKON POVREDE PERONEALNOG ŽIVCA

Živan Nikolić[1,2], Lukas Rasulić[1,3]

[1] Univerzitet u Beogradu, Medicinski fakultet, Beograd, Srbija
[2] Univerzitet odbrane, Vojnomedicinska akademija, Klinika za plastičnu hirurgiju i opekotine, Beograd, Srbija
[3] Univerzitetski klinički centar, Klinika za neurohirurgiju, Beograd, Srbija

Correspondence: zivan.nikolic@gmail.com

Abstract

Foot drop is a common clinical condition presented as an inability to lift the forefoot, characterized by the loss of ankle dorsiflexion from the tibialis anterior and loss of foot eversion from the peroneus longus and brevis muscles, followed by sensory loss or numbness of the foot dorsum. Causes of a foot drop can happen at any level of the nerve path. By their nature, lesions can be divided into compressive disorders, traumatic injuries, and neurologic disorders. Peroneal palsy, due to compression, is the most common peripheral cause. Treatment and diagnosis of foot drop still need to be better standardized, given that foot drop is still considered a clinical sign in other conditions. Regarding the multidisciplinary nature of foot drop, it can be challenging to determine the cause. Surgical and conservative treatments have their own respective places. Conservative procedures used for foot drop treatment include physical therapy, functional electrical stimulation, orthosis and braces, assistive devices, and gait training. Depending on a different etiological factor that causes foot drop, a few different surgical techniques are available for successful surgical treatment. Peroneal nerve release is considered a low-risk procedure with excellent results, such as pain relief and return of function. If the nerve continuity is not preserved, nerve repair with epineural stitches under magnification is performed. Another surgical approach proven successful in the literature is nerve transfer. The sural nerve is usually a donor graft. For tendon transfer tibialis posterior muscle is usually chosen. As it is inserted at the dorsum of the foot, it helps with dorsiflexion. After all surgical procedures, it is advised for patients to start with early mobilization and postoperative physical therapy. Better treatment standardization of foot drop is still needed. However, surgical procedures show high success rates, better results, and faster recovery if performed within the first months of injury.

Keywords:
foot drop,
surgical treatment,
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Sažetak

Pad stopala je često kliničko stanje koje se manifestuje nemogućnošću podizanja stopala, karakteristano gubitkom dorzifleksije skočnog zgloba od strane *m. tibialis anterior* i gubitkom everzije stopala od strane *m. peroneus longus* i *m. peroneus brevis*-a, praćeno gubitkom senzibiliteta ili utrnulošću dorzuma stopala. Uzroci pada stopala mogu se desiti na bilo kom delu puta nerva, a lezije se, prema prirodi, mogu podeliti na kompresivne poremećaje, traumatske povrede i neurološka oštećenja. Najčešći periferni uzrok je peronealna paraliza zbog kompresije nerva. Lečenje i dijagnoza pada stopala zahtevaju bolju standardizaciju, a pad stopala je i dalje klasifikovan kao klinički znak drugih oboljenja. Uzevši u obzir multidisciplinarnu prirodu pada stopala, nije uvek lako odrediti uzrok. U tretmanu pada stopala svoje mesto imaju kako konzervativno, tako i hirurško lečenje. Konzervativne procedure korišćene za lečenje pada stopala obuhvataju fizikalnu terapiju, funkcionalnu električnu stimulaciju, ortoze i proteze, pomoćne naprave i trening hoda. Zavisno od uzroka pada stopala, dostupno je nekoliko različitih hirurških tehnika za uspešno lečenje. Oslobađanje lišnjačnog živca smatra se procedurom niskog rizika sa odličnim rezultatima, kao što su umanjenje bola i povratak funkcije. Ako je kontinuitet nerva oštećen biće učinjena direktna sutura nerva epineuralnim šavovima pod uveličanjem. Transfer živca je još jedan hirurški pristup koji je u literaturi opisan kao uspešan. Uobičajeno se kao donor nervnog grafta koristi suralni nerv. Za transfer tetive najčešće se uzima m. tibialis posterior. Kako se tetiva prebacuje na dorzum stopala, pomaže pri dorzifleksiji. Nakon svih hirurških procedura, savetuje se da pacijenti počnu sa ranom mobilizacijom i postoperativnom fizikalnom terapijom. Bolja standardizacija terapije pada stopala je i dalje potrebna. Ipak, hirurške procedure pokazuju visok stepen uspešnosti, bolje rezultate i brži oporavak ukoliko se sprovedu unutar prvih nekoliko meseci od povrede.

Ključne reči:
pad stopala,
hirurško lečenje,
lišnjačni živac

Introduction

Foot drop is a common clinical condition presented as an inability to lift the forefoot. It is characterized by the loss of ankle dorsiflexion from the tibialis anterior and loss of foot eversion from the peroneus longus and brevis muscles, followed by sensory loss or numbness of the foot dorsum. Foot drop significantly impacts physical function and quality of life (1). Peroneal nerve palsy, due to compression, is the most common cause.

Anatomy

The common peroneal nerve (CPN) originates from L4, L5, S1, and S2 nerve roots. It continues as part of the sciatic nerve until the level of the thigh, where it branches off. It then proceeds through the posterior compartment until it reaches the popliteal fossa, where it separates from the tibial nerve. Here it curves around the fibula, passes through the intermuscular septum, and becomes superficial. At the level of the fibular neck, it divides into a superficial peroneal nerve (SPN), and deep peroneal nerve (DPN), and an articular branch (2). Both nerves proximity to the fibula and its bony structures make them susceptible to compression and the consequent muscular weakness of the muscles in their innervational region terminal branches provide sensitive innervation to the dorsum of the foot.

Etiology

Causes of a foot drop may be central, causes at the spinal cord or root level, and peripheral, occuring along the nerve pathway. Sometimes, double or multiple-level injuries can occur. By their nature, lesions can be divided into compression, trauma, and degenerative disease-related (3).

Central causes can develop on the underlying pathologies and are rarely seen isolated. Underlying processes can be characterized by compressive nature (tumor edema), destructive nature (hemorrhage, ischemia), or neurological disorder (ALS, Mononeuritis associated with infectious diseases, Guillain-Barre syndrome etc.) (4-8).

A recent study on patients who underwent lumbar disc herniation surgery concluded that almost one-fourth (22.9%) of patients suffered from foot drop (9). Other lesions on a spinal level that can cause foot drop include tumors, stenosis, and iatrogenic injuries.

The most common peripheral cause of foot drop is damage to the peroneal nerve. Also, the most common mononeuropathy of the leg is the peroneal. Damage may occur on any level from the nerve root and sciatic nerve to the foot (10). The cause may also be traumatic, iatrogenic injury, or idiopathic.

Diagnostics

Clinical Examination

Treatment and diagnosis of foot drop starts with a medical history and clinical examination of the patient. Regarding the multidisciplinary nature of foot drop, it can be challenging to determine the cause. It is good to remember that peroneal nerve injuries are the most common nerve injuries of the lower extremity. Manual muscle test (MMT) using MRC (Medical Research Council) scale

(11), muscle reflexes, sensory loss, and neurological testing are the basis of the clinical examination.

EMG and imaging

Essential roles and the next step in the assessment of clinical condition have electromyography (EMG), ultrasound examination, X-ray scanning, computed tomography (CT), and magnetic resonance imaging (MRI) (12). Imaging tests can identify structural abnormalities, spinal cord issues, and nerve compression. Electromyography is used to assess muscles' electrical activities and nerve conduction speed, which can help determine thepresence of nerve damage or compression.

Treatment

No guidelines exist for treating foot drop, and surgical and conservative treatments have their own respective places (13). The FOOTDROP prospective, multi-center randomized, parallel-group controlled trial aims to answer whether a patient recovers better from the surgical or conservative treatment of peroneal entrapment (14). Moreover, multiple retrospective studies prove good outcomes of both conservative and surgical treatment (15-21). Conservative procedures used for foot drop treatment include physical therapy, functional electrical stimulation (FES), orthosis and braces, assistive devices, and gait training (**Figure 1**).

Surgical Techniques

Depending on a different etiological factor that causes foot drop, a few different surgical techniques are available for successful surgical treatment. For example, if the nerve discontinuity is proven, it usually proceeds with nerve repair (direct nerve suture or nerve grafting). However, if the nerve continuity is preserved, a surgeon may continue with intraoperative nerve action potential (NAP) and then neurolysis (22).

Neurolysis

Peroneal nerve release is considered a low-risk procedure with excellent results, such as pain relief and return of function (23). It may happen on different anatomical levels. It includes compression of the CPN at the fibular neck, SPN at the calf, and DPN at the foot dorsum (24). It is indicated in patients with preserved nerve continuity and reinnervation capacity. It is usually performed through the popliteal approach. The type of neurolysis depends on intraoperative findings: external neurolysis is performed when PN is compressed by surrounding tissue and internal neurolysis in cases when there is intraneural fibrosis. After finishing neurolysis, hemostasis and wound closure in layers is performed. For this type of surgery, drainage is usually not needed (**Figure 2**).

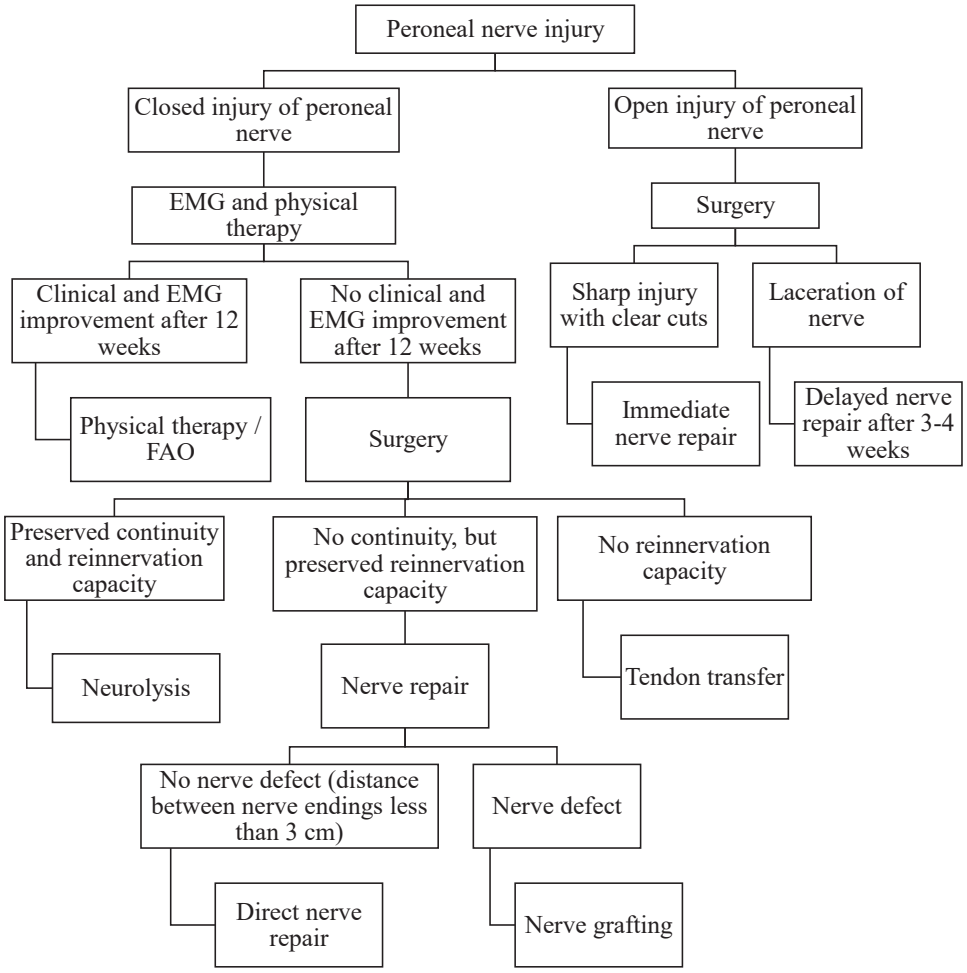

Figure 1. Algorithm for treatment of peroneal nerve injury

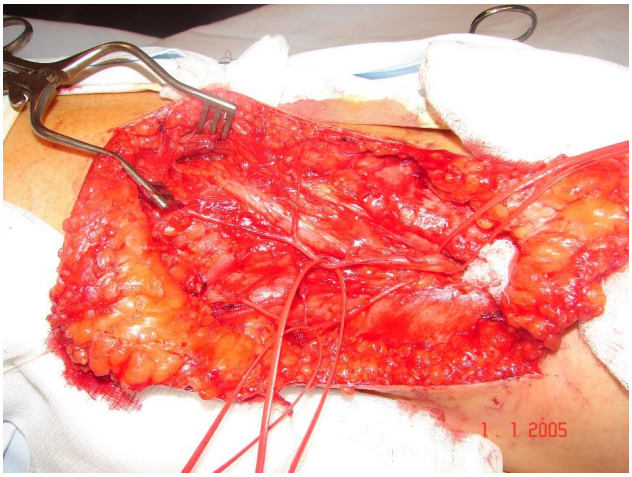

Figure 2. Peroneal nerve after external neurolysis

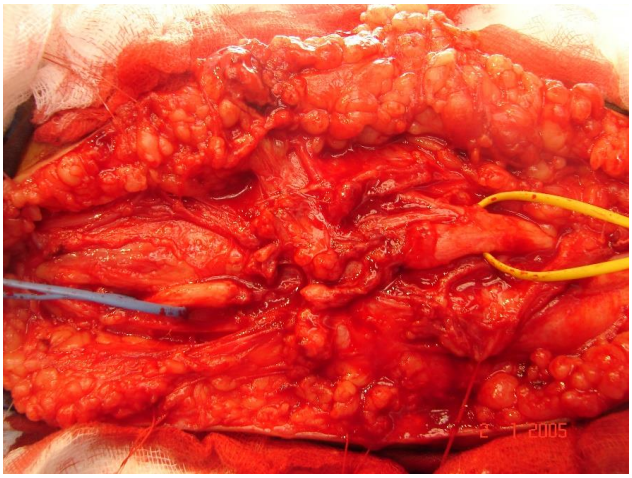

Figure 3. Proximal and distal ends of the injured peroneal nerve prepared for nerve grafting

Nerve repair and nerve grafting

If the nerve continuity is not preserved following nerve transection or secondary to nerve tumor excision, nerve repair with epineural stitches under magnification is performed. It is performed through the popliteal approach, the same as neurolysis. It is a very effective technique, but if the gap is more than 3 cm, and adequate coaptation of nerve ends without tension is not possible to achieve, it is required to perform nerve grafting. Usually, sural nerve graft is used, mostly from the same sided leg, but it is also possible to use other nerve grafts, when indicated. Two types of grafting are possible: cable grafting, in situations when the nerve defect is proximal to the ending branches, or interfascicular autografting, when the nerve defect includes ending branches. Ending of the operation includes hemostasis and wound closure in layered fashion. The best results are achieved with nerve grafts up to 6 cm in length (25). Moreover, grafts > 6 cm in length show a limited success rate in a study by Cho et al. (26) (**Figure 3**).

Nerve transfer

Another surgical approach proven successful in the literature is nerve transfer (27). Nerve transfer is performed through an incision on the back side of the knee joint. An incision is made vertically in the proximal part, curving towards the distal end along the path of the peroneal nerve. When the incision is made, the proximal pole sciatic nerve is identified and traced toward the bifurcation. In this way, it is possible to intraoperatively stimulate all nerve branches and prove which ones are affected. Depending on which nerves are injured, it is possible to take the superficial peroneal nerve as a donor for the deep peroneal nerve, or the tibial nerve could be a donor if both peroneal nerves are affected. This technique is performed in a microsurgical setting, usually securing the transfer site with 9-0 nylon stitches and followed by electrostimulation and physical therapy postoperatively.

Tendon transfer

Before the operative procedure, it is essential to assess the muscle strength of the anterior and lateral compartment muscles. Tibialis anterior, peroneus longus, and brevis, as well as the extensor hallucis longus (EHL) and extensor digitorum longus (EDL), are tested (28). The tibialis posterior muscle is usually chosen for tendon transfer. As it is inserted at the dorsum of the foot, it helps with dorsiflexion. There are multiple different routes for tendon transfer, as well as places of insertion, including the cuneiform bone, cuboid bone, and base of the second and third metatarsal bones (29, 30). It is advised to secure the tendon transfer with both bony anchorage and tendon suture with 2/0 sutures (31). This is followed by hemostasis and wound closure in a layered fashion. Above knee plaster immobilisation and foot and fingers in extension , is set and kept for 6 weeks postoperatively.

Postoperative period

After all surgical procedures, it is advised for patients to start with early mobilization and postoperative physical therapy. Also, patients will be given nerve repair supplement complexes after neurolysis and nerve repair techniques (32).

Conclusion

Both surgical and conservative approaches have their respective place in treating patients with foot drop. Even though much progress has been made in this field, more extensive studies and better treatment standardization of foot drop are still needed. However, surgical procedures show high success rates, better results, and faster recovery if performed within the first months of injury (33). When considering operative treatment, surgeons should also consider other prognostic factors, such as the patient' age or tibialis anterior muscle strength (34). A multidisciplinary approach and good cooperation between all healthcare professionals involved in treatment remain crucial for successful outcomes.

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