# Use of Dry Needling with Intramuscular Electrical Stimulation for Treatment of Peroneal Nerve Injury in an Adult Female: A Case Study

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Introduction:

Injuries to the peroneal nerve of the lower extremity can have a significant impact on quality of life due to changes that occur with gait, mobility, and fall risk. Peroneal nerve injuries most commonly occur as a result of direct compression to the nerve.[1] Traumatic peroneal nerve injuries have been documented in knee dislocations, gunshot wounds, and fibular/tibial plateau fractures as well as posteriolateral corner injuries to the knee.[2,3] Injuries due to prolonged compression of the nerve from leg crossing or tight fitting high-cut boots have been reported as well. In rare cases, surgeries such as total knee arthroplasties and ankle fixations have resulted in peroneal neuropathy.[4,5] Nerve traction injuries to the peroneal nerve are commonly associated with severe inversion ankle sprains.[6]

The common peroneal (also known as the fibular) nerve branches off the largest nerve in the body, the sciatic nerve. The common peroneal nerve wraps around the posterior aspect of the fibular head and branches between the superficial and deep peroneal nerves. The superficial branch innervates muscles in the lateral compartment of the lower leg that function primarily to evert the foot/ankle. The superficial peroneal nerve provides sensation to the anterolateral aspect of the lower leg and dorsolateral aspect of the foot. The deep peroneal nerve functions largely as an efferent nerve innervating muscle in the anterior compartment of the lower leg. Injuries to this nerve commonly result in paralysis of the dorsiflexors, a condition commonly known as drop foot.

Medical treatment for peroneal nerve injuries typically depends on the degree of injury to the nerve. Neurapraxia occurs when the injury temporarily blocks or slows nerve conduction, and full recovery is expected within six weeks.[7] Axonotmesis occurs when the axon has been partially damaged, and recovery is likely but may take months to years. Complete damage to the axon as well as the surrounding tissue is known as neurotmesis, an injury in which motor recovery is unlikely without surgical interventions.[7] In individuals with traumatic knee dislocations, complete peroneal nerve palsies have less than a 40% chance of regaining active motor recovery while complete recovery is typically seen in a majority of incomplete peroneal nerve palsies.[8] Medical management for peroneal nerve palsy is generally supportive in nature, but persistent weakness with complete peroneal nerve palsy may require a posterior tibial tendon transfer to regain active dorsiflexion.[1,8]

Supportive management of a peroneal nerve injury is best handled with interdisciplinary care between all relevant medical personnel. The goals of medical management typically focus on addressing gait and mobility limitations in daily activities, managing the pain and paresthesia, and preventing falls and contracture development.[9] Physical therapists play an integral role in the recovery of patients with this injury. Physical therapy for peripheral nerve injuries typically focuses on regaining strength and range of motion in the effected region as well as balance and proprioceptive deficits, pain management, and fall risk/contracture prevention.[10]

One of the common modalities used by physical therapists for the treatment of peripheral nerves injury is the use of electrotherapy targeted at the nerve or affected muscle groups.[11] There is evidence to support the use of transcutaneous neuromuscular electrical stimulation (NMES) in the treatment of neurological conditions such as spinal cord injury, stroke, peripheral nerve injuries, and peripheral nerve surgical neurorrhaphy.[11-14] NMES is typically used to prevent atrophy and improve function of the de-innervated muscles. Electrotherapy is expected to only be effective if partial nerve function is spared.[11]

Over the past two decades, more physical therapists have begun using dry needling as a modality to address myofascial and neurogenic pain and dysfunction. The body of literature to support the use of dry needling continues to grow significantly as dry needling now has strong evidence to support its use in the treatment of many musculoskeletal conditions such as cervicogenic headaches, neck pain, plantar heel pain, and low back pain.[15-20] Trigger point dry needling is performed by a trained practitioner and involves the needle being inserted into a trigger point or painful region within a muscle. Trigger point dry needling often results in a local reflexive twitch response to the muscle producing a mechanical change in the muscles length/tension through changes that occur locally at the neuromuscular junction.[21] The analgesic effects of needling are well-studied and are likely driven through changes that occur both peripherally and centrally in the nervous system.[21,22] Beyond the pain modulatory effects of dry needling, some studies have noted improvements in muscle strength, power, and endurance after dry needling.[23-25]

Electrotherapy can be combined with the use of dry needling by attaching electrodes to the needles while they are inserted into the muscle. Through direct electrical stimulation of the needle, an intramuscular motor twitch response can be observed. The combination of electrical stimulation and dry needling is commonly referred to as intramuscular electrical stimulation (IMES) or percutaneous electrical nerve stimulation (PENS). While modalities such as transcutaneous NMES, dry needling, and IMES continue to be well-studied within many populations, the effects of IMES for the use of treating peripheral nerve injuries is less understood. In the case study presented below, a patient with peroneal nerve dysfunction is first treated by performing NMES to the affected region for 1 month, followed by 1 month of IMES.

Additional supportive physical therapy interventions were provided throughout the entire plan of care.

Timeline:

The patient of interest was seen for initial evaluation on September 2, 2020 until discharge on December 9, 2020. The plan of care is summarized into two different phases due to changes that occurred regarding the plan of care and interventions provided at each phase. A progress note was performed at the termination of each phase and objective measures were taken throughout the plan of care.

Phase one spanned from September 2, 2020 to October 2, 2020 and included nine total sessions with one being the initial evaluation. The patient was seen two times weekly for one month. Phase two was initiated after the first progress note performed on October 2, 2020 and continued until discharge on December 9, 2020. This phase included 10 total sessions at a frequency of two times weekly for the first two weeks, then reducing to once weekly for the remaining weeks. A comprehensive outline of the timeline, along with the plan of care and interventions, is demonstrated in Tables 1 and 2 below.

**Patient:**

At the time, the patient was a seventy-eight-year-old Caucasian female. Her neurologist referred her to physical therapy with a diagnosis of left peroneal neuropathy that resulted from a fall sustained while on a walk three months prior to her physical therapy evaluation. The injury was described as a plantarflexion and inversion injury that occurred while stepping off a curb. Imaging was negative for a foot fracture. Swelling and pain in the foot had subsided since the injury but weakness, numbness, and gait impairments remained with no improvement over the prior three months. No red or yellow flags were present. Her past medical history was notable for hysterectomy, arthritis, and hypertension all of which are controlled and stable. She reported frequent walks around her neighborhood as her form of exerise.

Information:

At initial evaluation, the patient reported a primary complaint of difficulty walking with associated numbness and weakness in her right foot. The patient reported no known aggravating or easing factors for the numbness. The numbness was described as constant in nature and located along the dorsolateral aspect of her right ankle. Immediately following her fall she had more pain in the lateral and dorsum of her left foot as well as mild localized swelling; these particular symptoms had since resolved over the prior three months. The primary concern at the time of evaluation was ongoing right foot/ankle weakness, specifically with inability to dorsiflex her foot. She stated there was no pain present at the time of initial evaluation but reported some tenderness to the lateral aspect of her right knee that occured only with pressure to the area. The weakness and numbness ultimately limited her ability to walk normally, navigate unsteady surfaces, and return to her daily exercise routine.

The outcome measure used was the Lower Extremity Functional Scale (LEFS). This outcome measure is a validated tool used to assess patient-reported functional disability of the lower extremity. A score of 0/80 would indicate complete disability, whereas a score of 80/80 would indicate full function. At initial evaluation, the patient scored a 50/80 on the outcome measure.

Physical Exam:

Upon examination, the patient's primary impairments included left foot weakness and sensory changes, gait deviations, and balance impairments. Upon observation, the patient demonstrated a steppage gait pattern on the left leg with excessive knee/hip flexion during swing phase, no active dorsiflexion during swing phase, and forefoot landing at initial contact. There was minimal vaulting noted on the right leg during stance phase of gait. Neuro screening yielded no significant findings on the right lower extremity, however significant weakness and moderate atrophy were noted in her left everters and dorsiflexors. No additional myotome weakness was present, and she had intact bilateral reflexes at the achilles and quadriceps muscles. Slightly reduced sensation was present to light touch, and the patient reported mild paresthesia on the left foot which was present primarily distal to the ankle at the dorsolateral aspect of the foot.

Manual muscle testing (MMT) was performed in supine yielding palpable tibialis anterior contraction on the right but no active motion was present without compensation by the extensor digitorum muscles. The complete table of findings for foot/ankle MMTs are as follows:

| Foot/Ankle Manual Muscle Test Grading | | |
|---|---|---|
| | Right | Left |
| Dorsiflexion | 4+/5 | 1/5 |
| Plantarflexion | 4/5 | 4/5 |
| Inversion | 4+/5 | 4/5 |
| Eversion | 4+/5 | 2/5 |
| Great Toe Extension | N/T | 2/5 |

Passive range of motion assessment to the left foot was suggestive of both gastrocnemius and soleus mobility restrictions. Her foot and ankle active range of motion was tested in supine position. All foot and ankle active and passive motion measurements were within normal ranges with the exception of the following:

| Range of Motion assessment | | |
|---|---|---|
| | Right | Left |
| Dorsiflexion (15-25) | 10 degrees<br>(PROM 12degrees) | No motion present from resting position (PROM 8 degrees) |
| Plantarflexion (45-55) | WNL | WNL |
| Inversion (30-40) | WNL | WNL |
| Eversion (15-25) | 25 degrees | 5 degrees (PROM not tested) |

Palpation assessment reproduced pain of the lateral and posterior aspects of the fibular head on the right side with deep pressure to the area. At the time of the initial evaluation, she was able to perform Romberg stance with eyes open with ease. She was unable to perform single leg stance on her left without using her upper extremity or contralateral foot for support. Single leg stance on the right was within normal limits in duration.

**Interventions:**

At initial evaluation, the patient was sent home with a home exercise program including the following exercises: seated heel slides, bilateral hook-lying active dorsiflexion with strap assist, standing gastrocnemius stretch (see Appendix A).

Phase one included the initial evaluation and the first eight follow-up sessions after the initial evaluation. The patient was seen at a frequency of twice a week during this phase. The interventions focused on restoring passive and active range of motion, balance deficits, and passive neuro-motor facilitation of the tibialis anterior through use of NMES to the tibialis anterior (see Appendix B). The NMES parameters were set on Russian stimulation which is a time-modulated alternating current with a set frequency of 2500Htz modulated at 50bups with 10ms bursts. The on/off cycling was set for 10s/10s for a duration of eight minutes continuously. The intensity was adjusted based on the lowest intensity required to achieve a full motor contraction. The electrodes were placed on the proximal and distal aspect of the tibialis anterior (see Appendix B). The specific exercises and progressions are outlined in Table 1 and visualized in Appendix A.

In the final phase of treatment, the patient was seen twice a week for two weeks with the frequency reduced to once weekly thereafter. Active interventions focused on progressive strengthening, gait endurance and stability, and foot/ankle balance. The most notable change in this phase was the use of IMES with the addition of dry needling to the tibialis anterior. The needles were placed in the tibialis anterior muscle belly. One needle was place proximally in an anterior to posterior direction with a medial inclination (appendix B). The other needle was placed with the same direction and inclination at the distal end of the muscle approximately midway between the tibial plateau and ankle mortis. The electrical stimulation was hooked up to the needles and placed at a frequency of 2-3Hz. The intensity was increased until notable muscle twitches were observed in the tibialis anterior.

# Table 1: Phase 1 Interventions

| Phase 1 Interventions Part A | | | | |
|---|---|---|---|---|
| **Interventions** | eval 9/2 | 9-Sep | 11-Sep | 14-Sep |
| **Manual + Modalities** | Manual PROM and DF sustained stretch as tolerated | Manual PROM and DF sustained stretch as tolerated | Manual passive stretching. Standing talocrural joint AP glides with a mobiilizaiton with movement. Russian | Manual passive stretching. Standing talocrural joint AP glides with a mobiilizaiton with movement. Russian NMES 8 minutes |
| **Theraputic exericse** | Gastroc stretch | Gastroc stretch | Gastroc stretch | Gastroc stretch |
| | Heel slides | Heel slides | Heel slides | Standing soleus stretch |
| | hook lying DF AAROM with strap | hook lying DF AAROM with strap | hook lying DF AAROM with strap | hook lying DF AAROM with strap |
| | | Ankle 4way yellow (no DF) | Ankle 4way yellow (no DF) | Ankle 4way red (no DF) |
| | | Romburg stance with anterior/posterior weight shift | Romburg stance with anterior/posterior weight shift | Romburg stance with anterior/posterior weight shift |
| | | | | Bilateral heel raise |

| Phase 1 Interventions Part B | | | | | |
|---|---|---|---|---|---|
| **Interventions** | 18-Sep | 22-Sep | 25-Sep | 29-Sep | 2-Oct |
| **Manual + Modalities** | Manual passive stretching. Standing talocrural joint AP glides with a mobiilizaiton with movement. Russian NMES 10 minutes | Manual passive stretching. Standing talocrural joint AP glides with a mobiilizaiton with movement. Russian NMES 10 minutes | Manual passive stretching. Standing talocrural joint AP glides with a mobiilizaiton with movement. Russian | Manual passive stretching. Standing talocrural joint AP glides with a mobiilizaiton with movement. Russian NMES 10 minutes | Manual passive stretching. Standing talocrural joint AP glides with a mobiilizaiton with movement. Russian NMES 12 minutes |
| **Theraputic exericse** | Gastroc stretch | Gastroc stretch | Gastroc stretch | Gastroc stretch | Gastroc stretch |
| | Standing soleus stretch | Standing soleus stretch | Standing soleus stretch | Standing soleus stretch | Standing soleus stretch |
| | hook lying DF AAROM wth 5s hold | hook lying DF AAROM wth 5s hold | hook lying DF AAROM with 5s hold | hook lying DF AAROM with 5s hold + seated alt. | hook lying DF AAROM with 5s hold + seated alt. |
| | Ankle 4way red (no DF) | Ankle 4way red (no DF) | Ankle 4way red + IN/EV squeeze | Ankle 4way red + IN/EV squeeze | Ankle 4way red + IN/EV squeeze |
| | Romburg stance with anterior/posterior weight shift | Romburg stance with anterior/posterior weight shift | Romburg stance with anterior/posterior weight shift | Romburg stance with anterior/posterior weight shift | Romburg stance with anterior/posterior weight shift. Tandem stance |
| | Bilateral heel raise | Bilateral heel raise | Bilateral heel raise | Bilateral heel raise | Bilateral heel raise |

## Table 2: Phase 2 Interventions

| Phase 2 Interventions Part A | | | | |
|---|---|---|---|---|
| **Interventions** | 6-Oct | 8-Oct | 12-Oct | 15-Oct |
| **Manual + Modalities** | Manual PROM + Standing talocrural joint AP glides with a mobiilizaiton with movement. Dry needling to t ibialis anterior with IMES at 3 | Manual PROM. Dry needling to tibialis anterior with IMES at 3-4htz 10minutes | Dry needling to tibialis anterior with IMES at 3-4htz 10minutes | Dry needling to tibialis anterior with IMES at 3-4htz 10minutes |
| **Theraputic exericse** | Gastroc stretch | Gastroc stretch | Gastroc stretch | Gastroc stretch |
| | Standing soleus stretch | Standing soleus stretch | Standing soleus stretch | Standing soleus stretch |
| | hook lying DF AROM with 5s hold + seated alternating DF AROM | hook lying DF AROM with 5s hold + seated alternating DF AROM | hook lying DF AROM with 5s hold + seated alternating DF AROM | hook lying DF AROM with 5s hold + seated alternating DF AROM |
| | Ankle 4way red (no DF) + IN/EV squeeze | Ankle 4way red (no DF) + IN/EV squeeze | Ankle 4way red (no DF) + IN/EV squeeze | Ankle 4way red (yellow DF resistance) + IN/EV squeeze |
| | Romburg stance A/P shift, Single leg stance | Romburg stance A/P shift, tandem | Romburg stance A/P shift, Single leg stance | Romburg stance A/P shift, Single leg stance |
| | Billateral heel raise | Billateral heel raise | Bilateral heel raise + Toe raise | Bilateral heel raise + Toe raise |

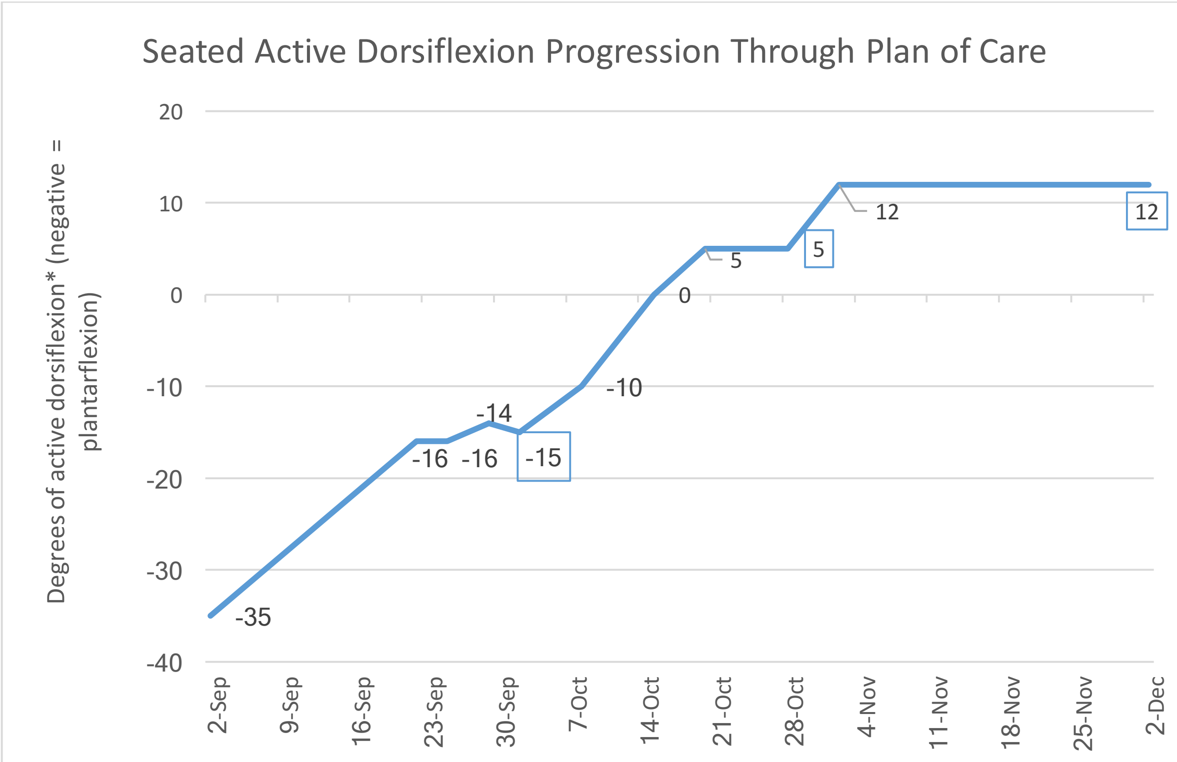
| Phase 2 Interventions Part B | | | | | |
|---|---|---|---|---|---|
| **Interventions** | 20-Oct | 28-Oct | 4-Nov | 2-Dec | D/C |
| **Manual + Modalities** | Dry needling to tibialis anterior with IMES at 3-4htz 10minutes | Dry needling to tibialis anterior with IMES at 3-4htz 10minutes | Dry needling to tibialis anterior with IMES at 3-4htz 10minutes | Dry needling to tibialis anterior with IMES at 3-4htz 10minutes | |
| **Theraputic exericse** | Gastroc stretch | Gastroc stretch | Gastroc stretch | Gastroc stretch | |
| | Standing soleus stretch | | | | |
| | hook lying DF AROM with 5s hold + seated ankle ABCs | hook lying DF AROM with 5s hold + seated ankle ABCs and circles | hook lying DF AROM with 5s hold + seated ankle ABCs and circles | hook lying DF AROM with 5s hold + seated ankle ABCs and circles | |
| | Ankle 4way red (yellow DF resistance) + IN/EV squeeze | Ankle 4way red (yellow DF resistance) + IN/EV squeeze | Ankle 4way red + IN/EV squeeze | Ankle 4way green + IN/EV squeeze | |
| | Romburg stance A/P shift, Single leg stance | Romburg stance A/P shift, Single leg stance | Romburg stance A/P shift, Single leg stance | Romburg stance A/P shift, Single leg stance | |
| | Bilateral heel raise + Toe raise | Bilateral heel raise + Toe raise | Bilateral heel raise + Toe raise | Bilateral heel raise + Toe raise with 5s hold | |

Abbreviation Index: Plantarflexion/Dorsiflexion = PF/DF; Eversion/inversion = EV/IN; Passive/Active range of motion = P/AROM; Active assisted range of motion = AAROM; AP = Anterior to posterior

Follow-up/Outcomes:

The primary objective outcomes measured throughout the plan of care were left ankle dorsiflexion AROM and PROM, strength, gait and balance, and the LEFS outcome measure. At initial evaluation, the patient had trace left ankle dorsiflexion with palpable contraction present (1/5) and no AROM noted in resting position. Her PROM was limited in left ankle dorsiflexion to eight degrees. Left great toe extension and ankle eversion strength was limited (2/5), and she was unable to perform a single leg stance on her left foot.

No updated objective measures were collected until the fifth treatment session. The following chart visualizes the change in left ankle dorsiflexion AROM throughout the plan of care. Dorsiflexion was tested in sitting position with the ankle starting at a resting position of 35 degrees of plantar flexion or -35 degrees dorsiflexion. In the chart below, active dorsiflexion is measured through a goniometric measurement of the ankle angle at the end of the attempted dorsiflexion. For example, -35 degrees of motion as reported at the initial evaluation on the chart below suggests the ankle did not actively move from a resting position of 35 degrees of plantar flexion; additionally, -16 degrees as listed on the chart below suggests active motion through 19 degrees of motion. The boxes denote the progress notes taken during the duration of care.




*Measurements assessed in sitting at a resting position of 35degrees plantarflexion

` The first progress note was performed at the ninth follow up session, which marked the transition from performing NMES to IMES. The patient's objective outcomes were as follows: (1) 59/80 on the LEFS, (2) -15 degrees of left foot active dorsiflexion, (3) inability to actively lift her metatarsal head off the ground in standing, (4) ankle dorsiflexion strength 2/5, and (5) left ankle PROM dorsiflexion to 14 degrees. She was still unable to tolerate single leg standing on the left leg and continued to demonstrate abnormal gait patterns. The transition from Russian stimulation to IMES was made due to the apparent plateau in AROM (noted in the chart above) over the prior four sessions before the first progress note was performed.

Phase two interventions were similar to that in phase one with the primary difference being the performance of intramuscular electrical stimulation in lieu of transdermal stimulation and progressive balance and strengthening only when resistance was tolerated. At the second progress note, the outcomes were as follows: (1) left foot active dorsiflexion to 5 degrees, (2) ability to actively lift her metatarsal head off the ground in standing, (3) ankle dorsiflexion strength 3-/5 (against gravity greater than halfway through available PROM), and (4) left ankle PROM dorsiflexion to 16 degrees. The patient was able to demonstrate normalized gait but fatigued quickly and reported no paresthesia.

Over the final three sessions the patient regained 12 degrees of left foot active dorsiflexion and demonstrated strength of 4/5 in her left ankle dorsiflexors, everters, and great toe extensors. She had no gait or balance abnormalities and a LEFS score of 80/80.

Discussion:

While there is a large amount of evidence to support the use of dry needling and IMES to reduce pain, the evidence to support the use of IMES over dry needling alone is conflicting and inconclusive.[26,27] In reference to neurophysiological changes noted in muscle size, strength/endurance, and function, the use of IMES or transcutaneous NMES is supported.[11-14, 24-26] However, no studies comparing the outcomes of transcutaneous versus intramuscular electrical stimulation were found on muscle function or pain modulation. As a result, there is currently no known evidence to support the use of IMES over NMES to address muscle weakness as pertaining to peripheral neuropathy.

This case study represents a clinical scenario in which NMES was performed to the tibialis anterior for approximately eight sessions with initial improvement noted followed by an early plateau in strength and AROM measurements. The plateau in improvement noted at the fifth through eighth follow-up sessions dictated the change to phase two interventions, which included the IMES. As noted in Table 2, the introduction of IMES in phase two coincided with a gradual return to full AROM in the dorsiflexors over the next eight sessions.

While the prognosis of eventual return to strength and function in partial peroneal nerve injuries is generally good (85%-100% full functional recovery), timeframes for recovery can vary widely based on the degree of damage to the nerve.[3,5] In the case study above, the patient had ongoing weakness, gait deficits, and numbness for three months prior to coming to physical therapy with no progress noted since the injury. Both NMES and IMES along with adjunctive exercises assisted in a near-full return to function within 16 visits and approximately three months. In this particular case study, the patient reported better perceived tolerance to IMES compared to NMES. Most importantly, she demonstrated a quick return of strength, range of motion, as well as gait and balance with no plateau noted until full functional recovery had been achieved after the switch from transcutaneous NMES to IMES. Based on the outcome of this case study, further research comparing the effects of IMES to transcutaneous NMES is needed in order to provide further insight into the clinical usefulness of these modalities for patients with peripheral neuropathies.

Limitations:

The first limitation of this case study is the uncontrolled variable of time when comparing the results of NMES to IMES. The patient was seen nearly the same amount of visits with NMES as IMES; however, due to adjustments in the plan of care, the patient was seen over a longer duration during the IMES treatments. As a result, the changes noted in strength, range of motion, and function are likely to be influenced by the timeframe of recovery as well.

Secondly, the literature demonstrates poor consensus regarding specific parameters for the use of NMES or IMES. The standardized parameters for Russian stimulation (listed in detail above) were subsequently performed. Certainly altering the pulse type, duration, and intensity may allow for more tolerable motor unit contractions in some individuals.

Finally, the primary outcome of interest—ankle dorsiflexion range of motion and strength—was assessed through consistent testing of ankle AROM and tolerance to overpressures using the manual muscle test grading system. Manual muscle testing grades are likely not specific enough measures to detect the incremental changes in strength that may be occurring. Standardized measurements using tools such as a push/pull dynamometer may allow for a more specific detection of strength changes, particularly when assessing for the higher manual muscle test grades.

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Appendix: A: Therapeutic exercises





Appendix: B: Electrode and needle placement