

Non-invasive Peripheral Neuromodulation in the Treatment of Post-Amputation Pain:

Prospective Case series from Two Centres in Ukraine

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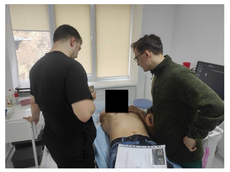
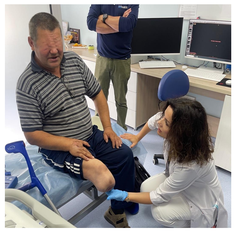
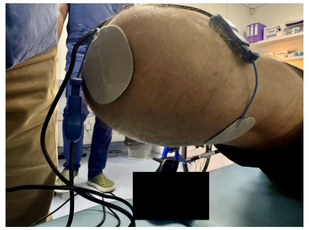
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BACKGROUND

The conflict between Ukraine and Russia has resulted in major military casualties secondary to blast injuries and battlefield related trauma. Post-amputation neuropathic pain —specifically residual limb pain and phantom limb pain —substantially impair health-related quality of life, delaying physical rehabilitation and prosthetic ambulation. Non-invasive peripheral neurostimulation has been implemented in two sites - Ivano-Frankivsk and Lviv in the management of post-amputation pain syndromes. We are analysing the pooled data of subjects with persistent post-amputation pain.



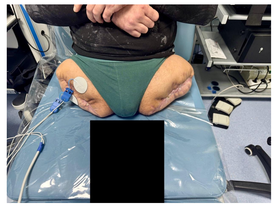




MATERIALS AND METHODS

Ethical clearance was formally granted on 06 June 2025 (Ivano-Frankivsk) and 30 June 2026 (Lviv). Data from a total cohort of 517 had a total of 259 patients with post-amputation pain syndromes (160/398 from Ivano-Frankivsk over 12 months and 99/119 from Lviv over 2 months) were reviewed. Subjects had undergone 30-minute therapeutic sessions utilizing a high-frequency neurostimulation device, delivered as targeted peripheral nerve stimulation (PNS) or peripheral field stimulation (PFS) via dedicated hydrogel electrodes or circumferential limb wraps. Stimulation was confirmed subjectively over the painful territory and titrated to the maximum tolerable intensity, with abolition of baseline pain perception as the endpoint. Pain scores were recorded at baseline, immediately post-treatment, at 24 and 48 hours. Functional prosthetic mobilization and biomechanical ease of movement were secondary endpoints. Patients residing in remote geographic locations were provisioned with portable neurostimulation units for self-administration, with longitudinal progress monitored via structured monthly telephone assessments. Longitudinal follow-up was conducted monthly via telephone until sustained analgesia was achieved; participants were advised to contact the clinic for additional support or treatments as needed. The study aimed to evaluate the immediate and short-term analgesic effects and functional outcomes associated with non-invasive peripheral neurostimulation in individuals with amputations related to battlefield injuries.







RESULTS

Amputation prevalence was 83.3% at the Lviv site as compared to over 38% at the Ivano-Frankivsk site, as the former was a specialist rehabilitation unit, with the latter having a mixed pain cohort. 70.6% were lower limb amputations (45.4% below-knee/ 25.2% above-knee), 29.4% were upper limbs (14.2% above elbow/ 12.8% below elbow) and 2.1% of toes. The number of bilateral amputees were similar in both sites (11.1% / 11.7%).

Total patients in the study population: 259 (160/99)

All participants tolerated the stimulation procedure well. A subset required higher stimulation intensities to achieve perceptual and/or therapeutic effects. Intensity was adjusted as per patient preference.

Baseline pain (visual analog scale, VAS) prior to treatment: mean 5.85 (5.90/5.82)

Immediately post-treatment: mean 1.67 (1.30/1.91) with pooled reduction (4.18 points) significantly above clinical and statistical threshold.

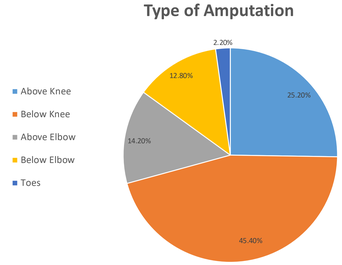
Mean duration of meaningful pain relief: 15.9 (19.0/13.9)

Repeat treatments: 76% patients underwent repeat stimulation sessions, with effects comparable to the initial treatment.

Among amputees, a substantial reduction in phantom-limb pain was observed after the initial treatment. Improved mobilisation with prosthetic devices was reported following treatment.

Sustained analgesic effects were recorded at 24 hours and 48 hours. The patient group at the Lviv site had better outcomes with 37% longer duration of effect, probably due to increased case mix of distal below knee amputations (67.2%) whilst the Ivano-Frankivsk had proportionally more above-knee and upper limb amputations (twice the number). Effectiveness appears inversely related to amputation proximity and upper limbs. Both sites independently confirm that a baseline VAS score of >6 predicts recurrent pain and would require regular repeated treatments.

The intervention demonstrated immediate and short-term reductions in pain with a trend toward increased functional accessibility for prosthetic-assisted mobilisation in amputees and reduced analgesic use. Prospective, longitudinal data are needed to ascertain sustained analgesic benefits, medication-sparing effects, durable functional improvements and improved quality of life in the long-term. This data is being collected as part of the long-term follow up and could be compared with civilian amputation data.



DISCUSSION

The patented electrical stimulation therapy modulates cutaneous electrical delivery by alternating two high-frequency (HF) carriers between two independent electrodes. As these carriers pass through the skin and deeper tissues, tissue polarization and the nonlinear electrodynamic properties of neuronal and muscular structures generate intermodulation products. The resulting frequency spectrum includes lower-frequency components produced by nonlinear mixing, effectively creating a low-frequency (LF) field beneath each electrode. Conceptually, this interaction zone forms a hemispherical region approximately three inches in diameter that encompasses local nociceptive pathways, potentially modulating axonal excitability and synaptic transmission. The proposed mechanism involves field-based interference with nociceptive signal propagation, producing analgesia by reducing peripheral nociceptive input to the central nervous system.

High-frequency non-invasive neurostimulation for post-amputation pain consistently delivered significant and reproducible analgesia, with a 72% reduction in pain sustained for 16 hours across 259 pooled patients. A baseline Visual Analogue Scale (VAS) score greater than 6 emerged as a consistent predictor of pain recurrence. However, repeated neurostimulation sessions still provided reliable and effective analgesia in these patients. These findings show that non-invasive neurostimulation is safe, easy to use, non-pharmacological, and cost-effective. It also facilitates opioid-sparing analgesia and improved functional outcomes. Further studies are needed to validate these results in civilian trauma and chronic pain conditions.

This cohort consists predominantly of military personnel who sustained shrapnel injuries from drone strikes, artillery shelling, and high-velocity gunshot trauma during the ongoing Ukraine–Russia conflict. Early intervention is being implemented to reduce comorbidity burden and to support mental health and overall well-being. Untreated chronic pain can compromise rehabilitation, mobility, and long-term quality of life. Plans are underway to expand the service to additional centres across Ukraine. Health professionals will also be trained to deliver non-invasive neurostimulation, building local capacity and ensuring the long-term sustainability of the programme. The primary objective is to monitor patient progress with a focus on improved mobility, durable pain relief, and the reduction or tapering of opioid and neuropathic pain medications. Outcomes will also be compared with analogous studies involving veterans from other countries to place these results in an international context. In addition, the team intends to explore whether this modality can benefit civilians undergoing amputation for peripheral vascular disease or diabetes, as well as those with traumatic amputations. This could considerably broaden its clinical impact beyond the military setting. Findings will be disseminated in due course through appropriate scientific and clinical channels.





CONCLUSIONS

Battlefield injuries, including amputations, receive prompt initial care, yet post-amputation and other neuropathic pain remain undertreated. Limited healthcare resources, specialist expertise gaps, supply chain disruptions, and ongoing conflict delay rehabilitation, impair mobilization, worsen mood, and sustain chronic pain. Early integration of non-invasive peripheral neurostimulation into pain protocols may mitigate these challenges, offering a non-pharmacological option deployable at the point of care or in remote, low-resource settings. High-frequency non-invasive neurostimulation for post-amputation pain delivered significant, reproducible analgesia: 72% pain reduction sustained for 16 hours across 259 pooled patients. Although baseline VAS > 6 consistently flagged pain recurrence, repeated sessions provided reliable relief. This safe, easy-to-use, cost-effective, scalable modality facilitates opioid-sparing analgesia, improved functional outcomes, and continued rehabilitation engagement with minimal adverse effects. Validation in civilian trauma and chronic conditions is warranted.

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