

# The utility of frequency-modulated electromagnetic neural stimulation as a third-line treatment in patients with painful diabetes-related peripheral neuropathy

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<b>Registration date</b> 16/01/2023	<b>Overall study status</b> Ongoing	<input type="checkbox"/> Statistical analysis plan <input type="checkbox"/> Results
<b>Last Edited</b> 19/05/2025	<b>Condition category</b> Nervous System Diseases	<input type="checkbox"/> Individual participant data <input checked="" type="checkbox"/> Record updated in last year

## Plain English summary of protocol

### Background and study aims

Diabetes mellitus (DM) is very common in the UK and globally and is a major healthcare challenge for the NHS. Diabetes UK announced that the number of people living with DM in the UK has more than doubled over the last 20 years, reaching 4.7 million in 2018, costing the NHS at least £10 billion a year, or 10% of the total NHS budget. The number of people living with DM is expected to reach 5 million in 2025 and 5.5 million in 2030, and the cost to the NHS is likely to increase significantly with this increased prevalence. Painful diabetes-related peripheral neuropathy (PDPN, damage to the nerves caused by high blood sugar levels) is a serious complication affecting 20-26% of patients with DM. PDPN has a major impact on quality of life, mood, sleep and relationships. This study aims to evaluate the clinical and cost-effectiveness of FREMS (frequency rhythmic electrical modulated system) in adults with PDPN.

### Who can participate?

Patients aged 18 years and over with diabetes mellitus and neuropathic pain affecting both feet for at least 3 months or taking pain medication for neuropathic pain for at least 3 months

### What does the study involve?

Participants are randomly allocated to receive 10 sessions of either transcutaneous electrical nerve stimulation (TENS) or FREMS treatment for 35 minutes each session. Follow-up is then up until 6 months.

### What are the possible benefits and risks of participating?

The researchers do not expect any safety issues or risks for the participants. The only risk associated with either intervention is in the potential for soreness at the point of application of the adhesive patches during and shortly after treatment; this risk remains the same for both arms. Offering the study to potential participants may prolong the clinic visit. The time taken for patients to receive their treatment can also be deemed as a potential burden but this additional time was felt to be within acceptable limits by patients and patient society representatives. Both

treatments could give some pain relief to patients. Participants will have the potential opportunity to try a new therapy before it is generally available.

Where is the study run from?  
University of Birmingham (UK)

When is the study starting and how long is it expected to run for?  
January 2022 to February 2027

Who is funding the study?  
National Institute for Health and Care Research (NIHR) (UK)

Who is the main contact?  
Ursula Ann Bobi, u.a.w.bobi@bham.ac.uk

**Study website**  
<https://frems.digitrial.com/>

## Contact information

**Type(s)**  
Scientific

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## Additional identifiers

**EudraCT/CTIS number**  
Nil known

**IRAS number**  
316524

**ClinicalTrials.gov number**  
Nil known

**Secondary identifying numbers**  
CPMS 53965, IRAS 316524, Grant Code: NIHR133599

# Study information

## Scientific Title

The utility of frequency-modulated electromagnetic neural stimulation as a third-line treatment in patients with painful diabetes-related peripheral neuropathy: a randomised controlled trial

## Acronym

FREMS-PDPN

## Study objectives

In patients with painful diabetes-related peripheral neuropathy (PDPN), frequency-modulated electromagnetic neural stimulation (FREMS) added to standard care as a third-line treatment (or higher) is superior to standard care in terms of reducing pain, improving sleep, improving quality of life (QoL) and reducing the use of medications, especially opioids.

## Ethics approval required

Old ethics approval format

## Ethics approval(s)

Approved 28/11/2022, London-Bromley Research Ethics Committee (Temple Quay House, 2 The Square, Temple Quay, Bristol, BS1 6PN, UK; +44 (0)2071048118, +44 (0)2071048140, +44 (0)2071048016; bromley.rec@hra.nhs.uk), ref: 22/LO/0683

## Study design

Randomized; Interventional; Design type: Treatment, Device

## Primary study design

Interventional

## Secondary study design

Randomised controlled trial

## Study setting(s)

Hospital

## Study type(s)

Treatment

## Participant information sheet

Not available in web format, please use the contact details to request a patient information sheet

## Health condition(s) or problem(s) studied

Painful diabetes-related peripheral neuropathy

## Interventions

Design: A pragmatic, multi-centre, two-arm, parallel-group, double-blind, sham-controlled, randomised trial with an internal pilot.

Target population: 356 adults with PDPN for  $\geq 3$  months with significant pain (mean pain Numerical Rating Scale [NRS]  $\geq 4$  for  $\leq 4$  weeks prior to randomisation) despite trying  $\geq 2$  different classes of PDPN medications.

Setting: NHS Trusts with PDPN services and aligned primary care and podiatry services.

Sub-study: Aimed at ensuring that there is no worsening sensory dysfunction with the trial interventions. The sub-study will also look for different responder rates in relation to the quantitative sensory testing (QST) phenotype. The sub-study will perform QST using the validated and standardised German Research Network on Neuropathic Pain (DFNS) protocol, which also has validated age and gender normative values

Treatment allocation: Participants will be individually randomised on a 1:1 basis between FREMS and transcutaneous electrical nerve stimulation (TENS) via a secure, online randomisation system based at Birmingham Clinical Trials Unit. A minimisation algorithm will be used within the randomisation system to ensure equal distribution.

Screening visits: The research team will take pre-screening consent and assess partial eligibility. Participants will be asked to complete a 7-day pain diary in order to confirm trial suitability. The patient will complete a pain diary at home via their personal device.

Baseline visit: If the patient is eligible to take part, the research team will take full trial informed consent, and complete outcome assessments and questionnaires with them at a baseline visit. The research team will record participants' personal details, medical history and current medication for randomisation. At randomisation trial treatment will be allocated, and started as soon as is practical for the participant.

Treatment phase: 10 x 35-minute sessions over a 2-week period.

Follow-up: Patients will be followed up at 3 and 6 months post-randomisation. During these visits patients will be asked to repeat some of the questionnaires and outcome assessments completed at the baseline visit. Patients will complete the daily pain diary via text message /email for the duration of the trial from pre-screening to 6-month follow-up.

Statistical analysis and sample size: 356 patients will be recruited in total. Up to 100 of these patients will take part in the QST sub-study. The justification for the sample size is based on the placebo response from RCTs in PDPN which is estimated to be 1.4 (95% CI 1.2 to 1.6) points reduction in pain severity based on NRS. To detect a mean difference of 0.6 points between groups at 3 months using the standard method of difference between means using a two-sided t-test and assuming a standard deviation of 1.65 (effect size 0.36) with 90% power and a type I error rate of 5%, a total of 160 participants per group will need to be randomised, 320 in total. Assuming and adjusting for a 10% attrition rate, 356 participants will need to be recruited (178 per group).

## **Intervention Type**

Device

## **Phase**

Not Applicable

## **Drug/device/biological/vaccine name(s)**

Frequency-Modulated Electromagnetic Neural Stimulation (FREMS) device

## **Primary outcome measure**

7-day average 24-hour pain on an 11-point NRS scale (0 = no pain and 10 = worst pain imaginable) measured at 3 months post-randomisation

## **Secondary outcome measures**

Current secondary outcome measures as of 15/04/2025:

Clinical:

1. 7-day average 24-hour pain measured on an 11-point NRS scale at the end of treatment and 6 months
2. Disease-specific quality of Life (QoL) measured using the Neuropathic Pain Impact on Quality-of-Life Questionnaire (NePIQoL) at 3 and 6 months
3. Treatment success (measured as a 30% reduction in 7-day average 24-hour pain scores) at the end of treatment, 3 and 6 months
4. Treatment success (measured as a 50% reduction in 7-day average 24-hour pain scores) at the end of treatment, 3 and 6 months
5. Area Under the Curve (AUC) for the daily NRS pain scores over the study period (from baseline to 3 months and from baseline to 6 months)
6. Pain interference with function measured using the Brief Pain Inventory-Diabetic Peripheral Neuropathy (BPI-DPN) at 3 and 6 months
7. Depression measured using the Beck Depression Inventory at 3 and 6 months
8. Sleep quality measured using the Pittsburgh Sleep Quality Index (PSQI) at 3 and 6 months
9. Pain intensity measured using the Neuropathic Pain Symptom Inventory (NPSI) at the end of treatment, 3 and 6 months.
10. Participant ratings of overall improvement, assessed by the Patients' Global Impression of Change (PGIC) and Clinician Global Impression of Change (CGIC) with a 7-point Likert scale at the end of treatment, 3 and 6 months
11. Changes to pain medications (frequencies and dosages) measured using patient-reported outcomes/clinical examination and interview with the patient at 3 and 6 months
12. Patient perception of their treatment arm, documented on the end-of-treatment participant case report form (CRF) by the patient. The patient has the option to select if they think they received FREMS or TENS. Measured at the end of the treatment phase.

Cost-effectiveness:

1. Health-related QoL assessed by the EQ-5D-5L at 6 months
2. Health resource use measured using the Health Economic Questionnaire at 3 and 6 months
3. Cost per quality-adjusted life year (QALY) gained over 6 months measured using the Health Economic Questionnaire

Subgroup outcomes:

Changes in overall PDPN and overall quality of life measured using the Neuropathic Pain Symptom Inventory (NPSI) questionnaire mean total score and mean subscores (burning, pressing, paroxysmal and evoked pain, paresthesia/dysesthesia) at end of treatment, 3 and 6 months

Safety:

1. Frequency and proportion of adverse events documented from the start of treatment until 7 days after the last treatment dose and will be reviewed for any changes in decreased pain and overall quality of life

2. Frequency of serious adverse events documented from the first treatment dose until the 6-month follow-up, to assess the safety of treatment/patient tolerance and overall treatment success/burden

Previous secondary outcome measures:

Clinical:

1. 7-day average 24-hour pain measured on an 11-point NRS scale at the end of treatment and at 6 months
2. Disease-specific quality of Life (QoL) measured using the Neuropathic Pain Impact on Quality-of-Life Questionnaire (NePIQoL) at 3 and 6 months
3. Treatment success (measured as a 30% reduction in 7-day average 24-hour pain scores) at end of treatment, 3 months and 6 months
4. Treatment success (measured as a 50% reduction in 7-day average 24-hour pain scores) at end of treatment, 3 months and 6 months.
5. Area Under the Curve (AUC) for the daily NRS pain scores over the study period (from baseline to 3 months and from baseline to 6 months)
6. Pain interference with function measured using the Brief Pain Inventory-Diabetic Peripheral Neuropathy (BPI-DPN) at 3 months and 6 months
7. Depression measured using the Beck Depression Inventory at 3 and 6 months
8. Sleep quality measured using the Pittsburgh Sleep Quality Index (PSQI) at 3 and 6 months
9. Participant ratings of overall improvement, assessed by the Patients' Global Impression of Change (PGIC) and Clinician Global Impression of Change (CGIC) with a 7-point Likert scale at end of treatment, 3 months and 6 months
10. Changes to pain medications (frequencies and dosages) measured using patient-reported outcomes/clinical examination and interview with the patient at 3 and 6 months
11. Patient perception of their treatment arm, documented on the end-of-treatment participant case report form (CRF) by the patient. The patient has the option to select if they think they received FREMS or TENS. Measured at the end of the treatment phase.

Cost-effectiveness:

1. Health-related QoL assessed by the EQ-5D-5L at 6 months
2. Health resource use measured using Health Economic Questionnaire at 3 and 6 months

Subgroup outcomes:

Changes in overall PDPN and overall quality of life measured using the Neuropathic Pain Symptom Inventory (NPSI) questionnaire mean total score and mean subscores (burning, pressing, paroxysmal and evoked pain, paresthesia/dysesthesia) at end of treatment, 3 months and 6 months

Safety:

1. Frequency and proportion of adverse events documented from the start of treatment until 7 days after the last treatment dose and will be reviewed for any changes in decreased pain and overall quality of life
2. Frequency of serious adverse events documented from the first treatment dose until the 6-month follow-up, to assess the safety of treatment/patient tolerance and overall treatment success/burden

**Overall study start date**

03/01/2022

**Completion date**

## Eligibility

### Key inclusion criteria

Current inclusion criteria as of 15/04/2025:

1. Aged  $\geq 18$  years
2. Neuropathic pain affecting both feet for  $\geq 3$  months or taking pain medication for neuropathic pain for  $\geq 3$  months
3. Mean pain score  $\geq 4$  on the daily NRS  $\leq 4$  weeks prior to randomisation
4. Douleur Neuropathique 4 (DN-4) questionnaire score  $\geq 4/10$  at screening to confirm the diagnosis of bilateral distal symmetrical neuropathic pain [70]
5. Diabetes-related neuropathy based on the Michigan Neuropathy Screening Instrument (MNSI) (MNSI questionnaire scored  $\geq 7$  or examination scored  $> 2$ ) [71, 72]
6. HbA1c  $< 108$  mmol/mol or 12% taken (within last 2 months).
7. Have tried at least two anti-neuropathic drugs from two different classes for PDPN
8. Willing and able to comply with the study schedule and be available for the treatment duration
9. Able to give written informed consent

Previous inclusion criteria:

1. Aged  $\geq 18$  years
2. Neuropathic pain affecting both feet for  $\geq 3$  months or taking pain medication for neuropathic pain for  $\geq 3$  months
3. Mean pain score  $\geq 4$  on the daily NRS for 1 week prior to randomisation
4. Douleur Neuropathique 4 (DN-4) questionnaire score  $\geq 4/10$  at screening to confirm the diagnosis of bilateral distal symmetrical neuropathic pain
5. Diabetes-related neuropathy based on the Michigan Neuropathy Screening Instrument (MNSI) (MNSI questionnaire scored  $\geq 7$  or examination scored  $> 2$ )
6. HbA1c  $< 108$  mmol/mol or 12% (within the last 2 months)
7. Have tried at least two drugs from two different classes for PDPN
8. Willing and able to comply with the study schedule and be available for the treatment duration
9. Able to give written informed consent

### Participant type(s)

Patient

### Age group

Adult

### Lower age limit

18 Years

### Sex

Both

### Target number of participants

Planned Sample Size: 356; UK Sample Size: 356

### Key exclusion criteria

Current exclusion criteria as of 15/04/2025:

1. Non-diabetic neuropathies

2. Currently using TENS for PDPN
3. History of epilepsy
4. Other painful medical conditions where the pain is significantly more severe than their PDPN pain (patients will not be excluded if the pain is transient in nature)
5. Major amputations of the lower limbs
6. Active diabetic foot ulcers
7. Active malignancy
8. Patient has a pacemaker, defibrillator or neurostimulator
9. Pregnancy

Previous exclusion criteria:

1. Non-diabetic neuropathies
2. Currently using TENS for PDPN
3. History of epilepsy
4. Other painful medical conditions where the pain is significantly more severe than their PDPN pain (patients will not be excluded if the pain is transient in nature)
5. Major amputations of the lower limbs
6. Active diabetic foot ulcers
7. Diagnosed malignancy
8. Pacemakers, defibrillator or neurostimulator
9. Pregnancy

**Date of first enrolment**

31/01/2023

**Date of final enrolment**

28/02/2026

## **Locations**

**Countries of recruitment**

England

United Kingdom

Wales

**Study participating centre**

**The Walton Centre**

Lower Lane

Fazakerley

Liverpool

United Kingdom

L9 7LJ

**Study participating centre**



**Heartlands Hospital**  
Bordesley Green East  
Bordesley Green  
Birmingham  
United Kingdom  
B9 5ST

**Study participating centre**  
**Ipswich Hospital**  
Heath Road  
Ipswich  
United Kingdom  
IP4 5PD

**Study participating centre**  
**Royal Hallamshire Hospital**  
Glossop Road  
Sheffield  
United Kingdom  
S10 2JF

**Study participating centre**  
**George Eliot Hospital**  
College Street  
Nuneaton  
United Kingdom  
CV10 7DJ

**Study participating centre**  
**Kings College Hospital**  
Mapother House  
De Crespigny Park  
Denmark Hill  
London  
United Kingdom  
SE5 8AB

**Study participating centre**  
**Manchester Diabetes, Endocrine and Metabolism Centre**  
Manchester Royal Infirmary  
Cobbett House

Oxford Road  
Manchester  
United Kingdom  
M13 9WL

**Study participating centre**

**Minerva Health Centre**

Lancashire and South Cumbria NHS Foundation Trust  
Sceptre Way  
Walton Summit  
Preston  
United Kingdom  
PR5 6AW

**Study participating centre**

**University Hospital of Wales**

Cardiff and Vale University Local Health Board  
Woodland House  
Cardiff  
United Kingdom  
CF14 4HH

**Study participating centre**

**Hywel Dda University Lhb**

Corporate Offices, Ystwyth Building  
Hafan Derwen  
St Davids Park, Jobswell Road  
Carmarthen  
United Kingdom  
SA31 3BB

## **Sponsor information**

**Organisation**

University of Birmingham

**Sponsor details**

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**Sponsor type**  
University/education

**Website**  
<http://www.birmingham.ac.uk/index.aspx>

**ROR**  
<https://ror.org/03angcq70>

## **Funder(s)**

**Funder type**  
Government

**Funder Name**  
NIHR Evaluation, Trials and Studies Co-ordinating Centre (NETSCC)

## **Results and Publications**

### **Publication and dissemination plan**

On completion of the trial, the data will be analysed, and a Final Study Report will be prepared. The results of this trial will be submitted for publication in a peer-reviewed journal. Manuscripts will be prepared by the writing group as defined in the trial publication plan. Any secondary publications and presentations prepared by Investigators must be reviewed and approved by the Trial Management Group (TMG). Manuscripts must be submitted to the TMG in a timely fashion and in advance of being submitted for publication, to allow time for review and resolution of any outstanding issues. The authors must acknowledge that the trial was performed with the support of NIHR HTA, the University of Birmingham (UoB) and the University of Birmingham Clinical Trials Unit (BCTU). Intellectual property rights will be addressed in the Clinical Trial Site Agreement between Sponsor and the site.

Results will also be sent to all participating centres, who will notify the participants recruited from their site. Participants will be invited to discuss the study results with the local research team.

**Intention to publish date**  
30/04/2026

**Individual participant data (IPD) sharing plan**

The final dataset will be available to members of the TMG and co-applicant group who need access to the data to undertake the final analyses.

Requests for data generated during this study will be considered by BCTU. Data will typically be available 6 months after the primary publication unless it is not possible to share the data. Only scientifically sound proposals from appropriately qualified Research Groups will be considered for data sharing. The request will be reviewed by the BCTU Data Sharing Committee in discussion with the CI and, where appropriate (or in absence of the CI) any of the following: the Trial Sponsor, the TMG, and the TSC.

A formal Data Sharing Agreement may be required between respective organisations once the release of the data is approved and before data can be released. Data will be fully de-identified (anonymised) unless the Data Sharing Agreement covers the transfer of participant-identifiable information. Any data transfer will use a secure and encrypted method.

**IPD sharing plan summary**  
Available on request

**Study outputs**

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
<a href="#">HRA research summary</a>			26/07/2023	No	No