

The use of different diagnostic tests for the detection of poor circulation in people with diabetes

Submission date 15/10/2021	Recruitment status No longer recruiting	☒ Prospectively registered ☐ Protocol
Registration date 18/10/2021	Overall study status Completed	☐ Statistical analysis plan ☒ Results
Last Edited 17/09/2025	Condition category Circulatory System	☐ Individual participant data

Plain English summary of protocol

Background and study aims

Diabetes is a lifelong condition that causes a person's blood sugar level to become too high. In people with diabetes, if high blood glucose levels are experienced over a period of years, blood vessels can become damaged which can lead to plaque forming in the blood vessels, rendering them unable to deliver enough blood to neighbouring cells. Poor blood circulation can lead to a higher chance of developing serious foot problems. In the UK there are over 7,000 leg amputations each year because of diabetes. The most important cause of this is poor circulation. The detection of poor circulation in patients with diabetes is difficult. A number of tests exist to detect poor circulation. However, there is confusion as to which is the best test. The aim of this study is to determine which test is best.

Who can participate?

Adult patients with diabetes

What does the study involve?

Patients will be asked to attend two study visits. At the first visit, which will take 40 minutes and coincide with a routine appointment, patients will undergo five tests:

1. Blood pressure at the ankle (called ankle-brachial pressure index or ABPI)
2. Blood pressure at the ankle after doing heel raises (called exercise ABPI)
3. Blood pressure at the big toe (called toe-brachial pressure index or TBPI)
4. Visible blood flow waveform (called Doppler)
5. Audible blood flow waveforms (called Doppler)

In some centres the researchers will also test the performance of an additional sixth test. They have developed this test and studied its performance in a study of 305 patients. It consists of an ultrasound test at the ankle, using a sensor and gel on the skin.

The second visit will take place within 2 weeks of the first visit. In the second visit, which will take 30 minutes, patients will have a more detailed scan of the blood vessels in their leg using a computed tomography angiography (CTA) or magnetic resonance angiography (MRA) scan. The results from the bedside tests will be compared to the results of the CTA or MRA to identify the most accurate test.

What are the possible benefits and risks of participating?

Participants will undergo comprehensive testing and imaging for peripheral arterial disease (poor circulation) as part of this study. If previously undiagnosed, the diagnosis of peripheral arterial disease may prompt their doctor to initiate medicines that will help reduce their chance of having a stroke, heart attack and worsening of their peripheral arterial disease.

Additionally, if participants are diagnosed as having peripheral arterial disease, they may be eligible for additional measures to reduce the risk of developing a foot ulcer. These additional measures may include more frequent foot checks or new footwear.

If participants have an active ulcer, a diagnosis of peripheral arterial disease will trigger a specialist review by a vascular surgeon for consideration of timely revascularisation to improve the chance of ulcer healing and reduce the risk of amputation.

Participants may have a Computed Tomography Angiography (CTA) procedure, which, for the majority of participants (about 80%), will be added to the procedures they would have if they did not take part. This procedure uses ionising radiation to form images of the body and provide the doctor with other clinical information. Ionising radiation may cause cancer many years or decades after the exposure. We are all at risk of developing cancer during our lifetime. 50% of the population is likely to develop one of the many forms of cancer at some stage during our lifetime. Taking part in this study may increase the chances of this happening to you to about 0.12% or 1 in 800.

Where is the study run from?

Imperial College London (UK)

When is the study starting and how long is it expected to run for?

September 2021 to February 2024

Who is funding the study?

National Institute for Health Research (NIHR) (UK)

Who is the main contact?

Laura Burgess, l.burgess@imperial.ac.uk

Contact information

Type(s)

Scientific

Contact name

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Contact details

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Additional identifiers

ClinicalTrials.gov (NCT)

NCT05009602

Integrated Research Application System (IRAS)

301408

Central Portfolio Management System (CPMS)

50623

National Institute for Health and Care Research (NIHR)

131855

Study information

Scientific Title

Diagnostic tools to establish the presence and severity of peripheral arterial disease in people with diabetes

Acronym

DM PAD 1.1

Study objectives

To determine the diagnostic performance of index tests (audible handheld Doppler, visual handheld Doppler, ankle-brachial pressure index [ABPI], exercise ABPI and toe brachial pressure index [TBPI]) for the diagnosis of peripheral arterial disease (PAD) in patients with diabetes as determined by a reference test (CTA or MRA).

Ethics approval required

Old ethics approval format

Ethics approval(s)

Approved 12/10/2021, London Central REC (3rd Floor, Barlow House, 4 Minshull Street, Manchester, M1 3DZ, UK; +44 (0)207 104 8225; londoncentral.rec@hra.nhs.uk), REC ref: 21/PR/1221

Primary study design

Interventional

Study design

Interventional randomized controlled trial

Study type(s)

Diagnostic

Health condition(s) or problem(s) studied

Peripheral arterial disease in people with diabetes

Interventions

VISIT 0 (REMOTE SCREENING)

To minimise patient burden, the researchers have adopted a remote screening process and incorporated the index tests into a routine visit episode to reduce the number of additional visits to one. Patients will be remotely screened at least 72 hours prior to their routine visit by their clinical team. If eligible for recruitment, they will be contacted by phone regarding the study. The study will be explained and if the patient gives verbal consent to receiving study information material, then these will be emailed or posted to the patient for consideration. They will be told that formal consent will be taken at visit 1 if they agree to partake in the study and that if they choose not to then this wouldn't affect their usual clinical care.

VISIT 1 (INDEX TESTS)

Visit 1 will occur at a planned/ routine visit i.e., this would have occurred regardless of whether the patient was recruited onto the study or not. Patients will undergo routine assessment and care by the local clinical team. There is some overlap regarding tasks that would be performed as part of routine/usual care and as part of the study. Such tasks will be highlighted as 'ROUTINE' when describing the order of events below. A routine visit usually lasts 30 minutes. The researchers expect that the study will add 40 minutes to the usual episode.

The researchers are primarily evaluating five index tests across all research centres; ABPI, expertise ABPI, TBPI, visual handheld Doppler and audible handheld Doppler. However, in four centres, they will evaluate the PAD scan as a sixth test. They have chosen not to evaluate this test at all centres as DUS machines are moderately costly and not currently available at every site. Index tests will be performed by a member of the local clinical team. Tests will be performed on one limb only; the most problematic side in symptomatic patients or randomly selected side in asymptomatic patients. Index tests will be performed in a predetermined order to minimise influence carrying over from one test to the other. Audible and visual handheld Doppler involve semi-objective interpretation of arterial waveforms and therefore could be influenced by knowledge of the tests with an objective output (TBPI, ABPI and exercise ABPI). Therefore, semi-objective tests will be performed first followed by objective tests

Order of events at visit 1:

- Eligibility check; 5 min
- Recording of demographic details and medical history; 5 min
- Assessment for neuropathy (ROUTINE); 5 min
- Assessment of diabetic foot ulcer severity, if relevant (ROUTINE); 5 min
- Index tests for the diagnosis of peripheral arterial disease:
 1. Audible handheld Doppler (ROUTINE); 5 min
 - 2a. Visual handheld Doppler; 5 min
 - 2b. PAD-scan (in 4 selected centres); 5 min
- *N.B the order of 2a. and 2b. will be randomised*
- 3. ABPI (ROUTINE); 5 min
- 4. TBPI; 5 min
- 5. Exercise ABPI i.e., ABPI performed following repetitive heel raising; 5 min
- Patient acceptability; patients will be asked to rate their experience of each test on a Likert scale
- Blood test to assess renal function (ROUTINE in a proportion of patients); 5 min
- Repeating of index tests (only performed in the first 100 volunteering patients); 40 min

The first 100 volunteering patients will have all index tests repeated (in the same leg) on the same day, by the same operator and also by an alternative operator to assess the inter- and intra-rater reliability.

VISIT 2 (REFERENCE TEST)

- MRI or CTA; 30 min

The reference test will be performed within 2 weeks of the index tests. The final decision regarding whether the patient undergoes CTA or MRA will depend on local protocol and patient choice. A proportion of patients would undergo a CTA or MRA regardless of whether they were taking part in the trial or not.

FOLLOW UP

Patients will be followed up 12 months from the time of the index tests. Follow up will be performed by review of the clinical notes. The purpose of follow up will be to ascertain whether the index tests can be used to predict ulcer healing, ulcer recurrence, revascularisation, amputation, cardiovascular events and mortality.

RECRUITMENT OF INPATIENTS

The above description is relevant to the recruitment of patients from clinics. The researchers will also be recruiting patients admitted for hospital care.

Patients admitted for inpatient hospital care will be first identified by the inpatient podiatry, vascular or diabetes teams.

Patients will have at least 24 hours to consider the patient information material. Participating patients will have index tests performed at their bedside. Where possible, the reference test will be performed during their inpatient stay to avoid additional hospital visits.

Intervention Type

Other

Primary outcome(s)

Diagnostic accuracy of the PAD scan and the other bedside tests for the diagnosis of peripheral arterial disease will be compared to the results of magnetic resonance angiography (MRA) or computed tomography angiography (CTA) (reference test) at 2 weeks

Key secondary outcome(s)

1. Health economic outcome - the cost of the test, including direct costs and amortisation of capital equipment and use of other healthcare resources for prevention and treatment of the disease over a time horizon of 5 years
2. Health economic outcome - incremental cost-effectiveness ratio at 5 years
3. Health economic outcome - Quality Adjusted Life Years at 5 years
4. Specificity of index tests, comparing index tests to reference tests at 2 weeks
5. Likelihood ratios of index tests, comparing index tests to reference tests at 2 weeks
6. Predictive values of index tests, comparing index tests to reference tests at 2 weeks
7. Diagnostic odds ratio of index tests, comparing index tests to reference tests at 2 weeks
8. Patient acceptability of each index test, measured on a Likert scale following the completion of the tests at visit 1
9. Technical success including inability to perform, refusal and discontinuation of tests at 2 weeks
10. Inter- and intra-rater reliability by repeating of index tests by the same and by an alternative operator for the assessment at 2 weeks

Completion date

14/02/2024

Eligibility

Key inclusion criteria

Known history of diabetes

Participant type(s)

Patient

Healthy volunteers allowed

No

Age group

Adult

Sex

All

Total final enrolment

604

Key exclusion criteria

1. Peripheral arterial disease (PAD) status known on imaging
2. Known history of PAD intervention
3. CTA and MRA contraindications; renal impairment, pregnancy, contrast medium hypersensitivity/allergy, non-compatible implants (MRA only)
4. Interim surgical interventions (occurring in the time interval between the index and reference tests) will be considered a protocol violation and patients will be excluded
5. Unable to provide appropriate informed consent

Date of first enrolment

01/03/2022

Date of final enrolment

28/02/2023

Locations**Countries of recruitment**

United Kingdom

England

Scotland

Wales

Study participating centre

St Mary's Hospital

South Wharf Road

London

United Kingdom
W2 1BL

Study participating centre
Chelsea & Westminster Hospital
369 Fulham Road
London
United Kingdom
SW10 9NH

Study participating centre
Leicester Royal Infirmary
Infirmary Square
Leicester
United Kingdom
LE1 5WW

Study participating centre
Southampton General Hospital
Tremona Road
Southampton
United Kingdom
SO16 6YD

Study participating centre
Hull Royal Infirmary
Anlaby Road
Hull
United Kingdom
HU3 2JZ

Study participating centre
Derriford Hospital
Derriford Road
Derriford
Plymouth
United Kingdom
PL6 8DH

Study participating centre
Worcestershire Royal Hospital
Charles Hastings Way
Worcester
United Kingdom
WR5 1DD

Study participating centre
James Cook University Hospital
Marton Road
Middlesbrough
United Kingdom
TS4 3BW

Study participating centre
Central London CCG - CLCH (NMP)
CLCH NHS Trust, 1 St Floor
5-7 Parsons Green
Fulham
United Kingdom
SW6 4UL

Study participating centre
Mid and South Essex NHS Foundation Trust
Prittlewell Chase
Westcliff-On-Sea
United Kingdom
SS0 0RY

Study participating centre
St George's Hospital
Blackshaw Rd
London
United Kingdom
SW17 0QT

Study participating centre
Cardiff Royal Infirmary
Newport Road

Cardiff
United Kingdom
CF24 0SZ

Study participating centre
Queen Elizabeth University Hospital
Govan Road
Glasgow
United Kingdom
G51 4TF

Study participating centre
Hammersmith & Fulham Health and Care Partnership
15 Marylebone Rd
London
United Kingdom
NW1 5JD

Study participating centre
Churchill Hospital
Old Road
Headington
Oxford
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OX3 7LE

Study participating centre
Royal Derby Hospital
Uttoxeter Road
Derby
United Kingdom
DE22 3NE

Sponsor information

Organisation
Imperial College London

ROR

Funder(s)

Funder type

Government

Funder Name

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

Funder Name

National Institute for Health Research (NIHR) (UK)

Alternative Name(s)

National Institute for Health Research, NIHR Research, NIHRresearch, NIHR - National Institute for Health Research, NIHR (The National Institute for Health and Care Research), NIHR

Funding Body Type

Government organisation

Funding Body Subtype

National government

Location

United Kingdom

Results and Publications

Individual participant data (IPD) sharing plan

The datasets generated and/or analysed during the current study during this study will be included in the subsequent results publication.

IPD sharing plan summary

Other

Study outputs

Output type	Details	Date created	Date added	Peer reviewed?	Patient-facing?
Basic results		13/08/2025	17/09/2025	No	No
HRA research summary			28/06/2023	No	No
Study website	Study website	11/11/2025	11/11/2025	No	Yes