

Reporting Summary

Nature Research wishes to improve the reproducibility of the work that we publish. This form provides structure for consistency and transparency in reporting. For further information on Nature Research policies, see our [Editorial Policies](#) and the [Editorial Policy Checklist](#).

Statistics

For all statistical analyses, confirm that the following items are present in the figure legend, table legend, main text, or Methods section.

- | | |
|-------------------------------------|--|
| n/a | Confirmed |
| ☐ | ☒ The exact sample size (n) for each experimental group/condition, given as a discrete number and unit of measurement |
| ☐ | ☒ A statement on whether measurements were taken from distinct samples or whether the same sample was measured repeatedly |
| ☐ | ☒ The statistical test(s) used AND whether they are one- or two-sided
<i>Only common tests should be described solely by name; describe more complex techniques in the Methods section.</i> |
| ☒ | ☐ A description of all covariates tested |
| ☐ | ☒ A description of any assumptions or corrections, such as tests of normality and adjustment for multiple comparisons |
| ☐ | ☒ A full description of the statistical parameters including central tendency (e.g. means) or other basic estimates (e.g. regression coefficient) AND variation (e.g. standard deviation) or associated estimates of uncertainty (e.g. confidence intervals) |
| ☐ | ☒ For null hypothesis testing, the test statistic (e.g. F , t , r) with confidence intervals, effect sizes, degrees of freedom and P value noted
<i>Give P values as exact values whenever suitable.</i> |
| ☒ | ☐ For Bayesian analysis, information on the choice of priors and Markov chain Monte Carlo settings |
| ☒ | ☐ For hierarchical and complex designs, identification of the appropriate level for tests and full reporting of outcomes |
| ☒ | ☐ Estimates of effect sizes (e.g. Cohen's d , Pearson's r), indicating how they were calculated |

Our web collection on [statistics for biologists](#) contains articles on many of the points above.

Software and code

Policy information about [availability of computer code](#)

Data collection ECG signal was obtained using LabChart (ADInstruments). Optical mapping data was obtained by the MiCAM05 camera system (SciMedia).

Data analysis Finite element analysis (FEA) was implemented on the commercial software COMSOL 5.2a for electric field distribution in heart tissue. Optical signals were processed using a custom MATLAB software called "RHYTHM" which is freely available on GitHub at <https://github.com/optocardiography>. Mechanical simulation was conducted using ABAQUS (Analysis User's Manual 2016). Electromagnetic simulation was calculated using ANSYS HFSS (ANSYS). Statistical analyses were performed using Statistical software (Version 6.0, Statsoft, Tulsa, Oklahoma) followed by a t-test. * $P < 0.05$, * $P < 0.01$, *** $P < 0.001$. Masson's trichrome stain analysis was performed using a custom MATLAB program to implement color deconvolution for quantification. Immunohistochemistry quantification of CD45+ cells was performed manually using ImageJ v2.1.0. Quantification of myocardial area in immunostained images was performed using a custom MATLAB program where color deconvolution was implemented.

For manuscripts utilizing custom algorithms or software that are central to the research but not yet described in published literature, software must be made available to editors and reviewers. We strongly encourage code deposition in a community repository (e.g. GitHub). See the Nature Research [guidelines for submitting code & software](#) for further information.

Data

Policy information about [availability of data](#)

All manuscripts must include a [data availability statement](#). This statement should provide the following information, where applicable:

- Accession codes, unique identifiers, or web links for publicly available datasets
- A list of figures that have associated raw data
- A description of any restrictions on data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request. Optical mapping data analysis software is openly available at <https://github.com/optocardiography>.

Field-specific reporting

Please select the one below that is the best fit for your research. If you are not sure, read the appropriate sections before making your selection.

☒ Life sciences ☐ Behavioural & social sciences ☐ Ecological, evolutionary & environmental sciences

For a reference copy of the document with all sections, see nature.com/documents/nr-reporting-summary-flat.pdf

Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size	For in vivo demonstrations, a minimum number of n=3 rats and canines per group were utilized. For some key experiments, sample size was increased to n=6 rats per group. Exceptionally, in case of ex vivo optical mapping (Fig. 2 c,f,i, Fig. 3c and Fig. S4), authors conducted 1 successful demonstration because of the proof-of-concept nature of the studies (n=1).
Data exclusions	No data points were excluded from analysis.
Replication	ECG signals were obtained in multiple groups of laboratory animals. The devices performed similarly across several groups of animals.
Randomization	All animals were randomized into experimental groups. Groups were counterbalanced for animal sex and group average body weight. Additional information is provided in the Online Methods section and in the Supplementary Note. Human cardiac tissue was de-identified prior to procurement for research.
Blinding	All assessments of ECG were continuously recorded in a blinded manner. Personnel completing quantitative analysis of the Masson's trichrome stained samples and the immunohistochemistry stained samples were blinded to experimental groupings. For optical mapping experiments, blinding was not possible because the experimental results are immediately evident from the image data.

Reporting for specific materials, systems and methods

We require information from authors about some types of materials, experimental systems and methods used in many studies. Here, indicate whether each material, system or method listed is relevant to your study. If you are not sure if a list item applies to your research, read the appropriate section before selecting a response.

Materials & experimental systems

n/a	Involved in the study
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology and archaeology
☐	☒ Animals and other organisms
☒	☐ Human research participants
☒	☐ Clinical data
☒	☐ Dual use research of concern

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Animals and other organisms

Policy information about [studies involving animals](#); [ARRIVE guidelines](#) recommended for reporting animal research

Laboratory animals	Adult Sprague-Dawley rats (male and female, 250-500 g), acquired from Hilltop Animals (Scottsdale, PA), were used in the studies of in vivo cardiac pacing with implantation of bioresorbable stimulator. Adult C57BL/6 background mice (male and female, 25-35 g) and adult New Zealand white rabbits (age: 3-6 months, female, 3-4 kg), acquired from Covance (Denver, PA, USA) were used for ex vivo demonstrations. Canine model (adult hound dogs, age 1.2-3.5 years, female, 27-36 kg) was used for demonstration of open chest surgery.
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Procurement Left ventricular cardiac tissue from adult human hearts rejected for organ transplant was coordinated by the Washington Regional Transplant Community.

Wild animals

The study did not involve wild animals.

Field-collected samples

The study did not involve samples collected from the field.

Ethics oversight

All biocompatibility tests were approved by the Institutional Animal Care and Use Committee (IACUC) of The George Washington University and conform with guidance from the Guide for Care and Use of Laboratory Animals published by the National Institutes of Health (NIH).

All human heart tissue procurement, preparation, and experiments are performed according to protocols approved by the Institutional Review Board (IRB) of The George Washington University and international guidelines for human welfare. Donor human hearts rejected for organ transplant were acquired from the Washington Regional Transplant Community (WRTC) as de-identified discarded tissue with approval from IRB of The George Washington University.

Note that full information on the approval of the study protocol must also be provided in the manuscript.