nature portfolio

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Reporting Summary

Nature Portfolio 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 Portfolio 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 *Only common tests should be described solely by name; describe more complex techniques in the Methods section.*
☐	☒ 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 *Give P values as exact values whenever suitable.*
☐	☒ 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	ImageJ 1.53t Software; OLYMPUS OlyVIA 3.2 Imaging Software; NIS-Elements 5.21.00 Imaging Software; ZEN 3.8.1 Imaging Software; K-Viewer V1 1.5.3.1 Software.
Data analysis	Graphpad Prism 10.1.2 software; ImageJ 1.53t Software.

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 Portfolio 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 description of any restrictions on data availability
- For clinical datasets or third party data, please ensure that the statement adheres to our policy

The mass spectrometry proteomics data that substantiate the findings of this study have been submitted to the ProteomeXchange Consortium via the iProx partner repository, where they have been assigned the dataset identifier or primary accession code PXD057558. All other data that support the results of this study are available upon request from the corresponding author.

Research involving human participants, their data, or biological material

Policy information about studies with human participants or human data. See also policy information about sex, gender (identity/presentation), and sexual orientation and race, ethnicity and racism.

Reporting on sex and gender	The cellular experiments in this study did not address gender differences, and the clinical samples were analysed according to the type of disease only, with no consideration of sex or gender.
Reporting on race, ethnicity, or other socially relevant groupings	This study solely examined at GBM samples from patients and did not address race, ethnicity, or racist content.
Population characteristics	This study solely examined at GBM samples from patients and did not address race, ethnicity, or racist content.
Recruitment	The GBM specimens utilised in this study were obtained from patients at Southwest Medical University Hospital, without any potential for self-selection bias.
Ethics oversight	The study protocol was approved by the Clinical Trial Ethics Committee of the Affiliated Hospital of Southwest Medical University.

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

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	Each experiment in this study had a sample size of at least 3.
Data exclusions	No data exclusions were made in this study.
Replication	All results from this experiment were repeated more than three times and the results can be replicated.
Randomization	The samples were divided randomly into experimental and control groups.
Blinding	The investigators in this study were blinded to group allocation during data collection and analysis.

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
☒	☐ Clinical data
☒	☐ Dual use research of concern
☒	☐ Plants

Methods

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

Antibodies

Antibodies used	nti-TSPAN4 (abcam, Cat#ab181995,1:1000)，anti-NDST1 (Proteintech, Cat#26203-1-AP,1:1000), anti-Integrin Alpha-5 (Proteintech, Cat#10569-1-AP, 1:1000), anti-GAPDH (Servicebio, Cat#GB15004, 1:1000), anti-CPQ (Prote.intech, Cat#16601-1-AP,1:1000),

	antiCalnexin (Cell Signaling Technology, Cat#2679T,1:1000), anti-LAMA4 (Invitrogen, Cat#PA5-112926, 1:1000),anti-TSG101 (Bioss, Cat#bs-1365R, 1:1000), anti-PAK4 (Proteintech, Cat#14685-1-AP,1:1000), anti-β-actin (Proteintech, Cat#81115-1-RR,1:5000),and anti-rabbit IgG secondary antibody(Cell Signaling Technology, Cat#5151P, 1:30000).
Validation	anti-TSPAN4 (RRID: AB_10697725), anti-NDST1 (RRID: AB_2880423), anti- Integrin Alpha-5 (RRID: AB_2130060), anti-GAPDH (RRID: AB_2943040), anti-CPQ (RRID: AB_2160929), anti-Calnexin (RRID: AB_2228381), anti-LAMA4 (RRID: AB_2867660), anti-TSG101 (RRID: AB_10855432), anti-PAK4 (RRID: AB_2158610), anti-β-actin (RRID: AB_2923704), anti-rabbit IgG secondary antibody (RRID: AB_2556775).

Eukaryotic cell lines

Policy information about cell lines and Sex and Gender in Research

Cell line source(s)	LN-229 cell line, Homo sapiens, Brain, Female (RRID:CVCL_0393); U373 (RRID:CVCL_2219); U251 (RRID:CVCL_0021); U87 (RRID:CVCL_0022); T98 (RRID: CVCL_0556).
Authentication	LN-229 cell line (STR Authentication: CRL-2611); U373 (STR Authentication: HTB-17); U251 (STR Authentication: IFO50288); U87(RRID: GDC0157); T98(RRID: CRL-1690).
Mycoplasma contamination	Negative for mycoplasma contamination in each cell line.
Commonly misidentified lines (See ICLAC register)	There are no commonly misidentified lines in this study.

Animals and other research organisms

Policy information about studies involving animals; ARRIVE guidelines recommended for reporting animal research, and Sex and Gender in Research

Laboratory animals	BALB/c-Nude mices, famale, 4 week old.
Wild animals	Wild animals were not involved in this study.
Reporting on sex	This study did not apply to only one sex and did not consider sex, assign sex, or collect sex-specific data during the experimental design.
Field-collected samples	This study did not involve samples collected from the field.
Ethics oversight	All study protocols were approved by the Animal Ethics Committee of the Southwest Medical University.

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

Plants

Seed stocks	Plants were not involved in this study
Novel plant genotypes	Plants were not involved in this study
Authentication	Plants were not involved in this study