

Supplementary Materials

Glioblastoma: Pathogenesis and Current Status of Chemo and Other Novel Therapies

Vilashini Rajaratnam, Mohammad Mohiminul Islam, Maixee Yang, Rachel Slaby, Hilda Martinez Ramirez, and Shama Parveen Mirza

Table S1. Ongoing clinical trials of targeted therapeutic agents summarized from www.clinicaltrials.gov. The details are collected from corresponding clinical trials and www.cancer.gov. The superscript numbers are unique for the therapeutic agents listed in Table S1 and are used to identify an agent in case of repeated presence in the table. They are unrelated to the superscript numbering used in Table 1.

Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
¹² OHOA	¹² hydroxy oleic acid, activates sphingomyelin synthase	Primary	I	September 2023	NCT03867123
²⁵ Flucytosine, ³ TG6002	² Fluorinated cytosine analog, inhibits thymidylate synthetase; ³ Oncolytic virus	Recurrent	I/II	September 2021	NCT03294486
⁴⁹ ING-41	⁴ GSK-3 β inhibitor	-	I/II	November 2022	NCT03678883
⁵ ABBV-321	⁵ Antibody-drug conjugate, targets EGFR	-	I	August 2023	NCT03234712
⁶ Abemaciclib	⁶ CDK inhibitor	Recurrent	II	April 2022	NCT02981940
⁶ Abemaciclib, ⁷ CC-115, ⁸ Neratinib	⁷ DNA-pk and mTOR inhibitor; ⁸ Tyrosine kinase inhibitor	-	II	May 2021	NCT02977780
⁹ ABI-009	⁹ mTOR inhibitor	Primary	II	June 2021	NCT03463265
¹⁰ ACP-196	¹⁰ Bruton's tyrosine kinase (Btk) inhibitor	Recurrent	Ib/II	December 2019	NCT02586857
¹¹ Adavosertib	¹¹ Trosine kinase WEE1 inhibitor	Primary	I	October 2021	NCT01922076
¹¹ Adavosertib	-	Recurrent	I	February 2020	NCT01849146
¹² Ad-hCMV-TK, ¹³ AdhCMV-Fit3L	¹² Adenoviral vector engineered to express HSV-tk; ¹³ Adenoviral vector engineered to express Flt3L	Primary	I	December 2020	NCT01811992
¹⁴ Ad-RTS-hIL-12	¹⁴ Adenoviral vector encoding hIL-12	Recurrent	I	December 2019	NCT02026271

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¹⁴ Ad-RTS-hIL-12	-	-	I	March 2021	NCT03330197
¹⁴ Ad-RTS-hIL-12, ¹⁵ Nivolumab, ¹⁶ Veledimex	¹⁵ Immune checkpoint inhibitor that binds to PD-1; ¹⁶ Diacylhydrazine-based activator ligand that binds to RheoSwitch Therapeutic System (RTS)	Recurrent	I	December 2021	NCT03636477
¹⁷ ADV/HSV-tk	¹⁷ Gene therapy	Primary	I/II	December 2025	NCT03603405
¹⁷ ADV/HSV-tk	-	Recurrent	I	December 2025	NCT03596086
¹⁸ AdV-tk, ¹⁵ Nivolumab, ¹⁹ Temozolomide, ²⁰ Valacyclovir	¹⁸ Gene therapy; ¹⁹ DNA Alkylating agent; ²⁰ Antiviral prodrug, inhibits viral DNA polymerase	Primary	I	January 2022	NCT03576612
²¹ Afatinib	²¹ Tyrosine kinase inhibitor	Recurrent	I	December 2020	NCT02423525
²² Aldesleukin, ²³ Cyclophosphamide, ²⁴ Fludarabine	²² Recombinant human interleukin-2; ²³ Synthetic DNA alkylating agent; ²⁴ DNA polymerase inhibitor	-	II	March 2028	NCT03412877
²² Aldesleukin, ²³ Cyclophosphamide, ²⁴ Fludarabine, ²⁵ Pembrolizumab, ²⁶ Young TIL	²⁵ Humanized monoclonal antibody, inhibitor of PD-1 receptor; ²⁶ TIL: Therapeutic tumor infiltrating lymphocyte	-	II	December 2024	NCT01174121
²⁷ ALECSAT	²⁷ ALECSAT: Autologous lymphoid effector cells specific against tumor	Primary	II	June 2021	NCT02799238
²⁸ Alectinib, ²⁹ APG101, ³⁰ Atezolizumab, ³¹ Idasanutlin, ³² Palbociclib, ³³ Temsirolimus, ³⁴ Vismodegib	²⁸ Tyrosine kinase inhibitor; ²⁹ inhibitor of CD95L from binding to CD95 receptor; ³⁰ Humanized monoclonal antibody; ³¹ Antagonist of MDM2 (mouse double minute 2); ³² Cyclin-dependent kinase inhibitor; ³³ mTOR inhibitor; ³⁴ Antagonist of the Hedgehog-ligand cell surface receptors PTCH and/or SMO	Primary	I/II	September 2024	NCT03158389

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³⁵ (Allogeneic Hematopoietic Stem Cells, Cytotoxic Lymphocytes, Dendritic Vaccine)	³⁵ Proteome based personalized immunotherapy	-	II/III	December 2020	NCT01759810
³⁶ AMG 596	³⁶ Anti-EGFRvIII/CD3 BiTE antibody	Primary/Recurrent	I	April 2021	NCT03296696
³⁷ AMG-232	³⁷ MDM2 inhibitor	Primary/Recurrent	I	June 2020	NCT03107780
³⁸ Anti-EGFRvIII CAR T cells, ²³ Cyclophosphamide, ²⁴ Fludarabine	³⁸ Anti-EGFRvIII CAR-transduced allogeneic T lymphocytes	Recurrent	I	July 2019	NCT02844062
³⁹ Antigen-specific IgT cells	³⁹ Immunogene-modified T cells	-	I	December 2020	NCT03170141
⁴⁰ Anti-PD-L1 CSR T Cells, ²³ Cyclophosphamide, ²⁴ Fludarabine	⁴⁰ Autologous chimeric switch receptor modified T cells	Recurrent	I	July 2019	NCT02937844
⁴¹ Apatinib	⁴¹ Tyrosine kinase inhibitor	-	-	October 2019	NCT03567135
⁴² Aprepitant, ⁴³ Minocycline, ⁴⁴ Disulfiram, ⁴⁵ Celecoxib, ⁴⁶ Sertraline, ⁴⁷ Captopril, ⁴⁸ Itraconazole, ⁴⁹ Ritonavir, ⁵⁰ Auranofin	⁴² Substance P inhibitor; ⁴³ Inhibits binding tRNA to the ribosomal complex, inhibits the enzyme 5-lipoxygenase (5LOX); ⁴⁴ Proteasome inhibitor; ⁴⁵ Cyclo-oxygenase (COX-2) inhibitor; ⁴⁶ Selective serotonin reuptake inhibitor; ⁴⁷ Angiotensin converting enzyme inhibitor; ⁴⁸ Inhibitor of fugal cytochrome P450 enzymes; ⁴⁹ Anti-HIV and a type of protease inhibitor; ⁵⁰ Inhibits the activity of mitochondrial thioredoxin reductase (TrxR)	Recurrent	I	March 2020	NCT02770378
⁵¹ APX005M	⁵¹ CD40 agonistic monoclonal antibody	Recurrent	I	September 2022	NCT03389802
Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier

⁵² Arsenic trioxide	⁵² Damages the promyelocytic leukemia protein/ retinoic acid receptor-alpha fusion protein	-	I/II	May 2021	NCT00275067
⁵³ Ascorbate	⁵³ Causes oxidative stress	-	I	December 2021	NCT01752491
⁵³ Ascorbic Acid	-	-	II	December 2023	NCT02344355
⁵⁴ Atezolizumab	⁵⁴ Humanized monoclonal antibody, inhibits PD-L1 from binding to PD-1	Primary	I/II	June 2020	NCT03174197
⁵⁴ Atezolizumab, ⁵⁵ Ipatasertib	⁵⁵ Inhibitor of protein kinase B	-	I	November 2020	NCT03673787
⁵⁴ Atezolizumab, ⁵⁶ PVSRIP0	⁵⁶ Polio/Rhinovirus Recombinant	Recurrent	I/II	July 2023	NCT03973879
⁵⁷ Avelumab	⁵⁷ Human IgG1 monoclonal antibody, inhibits interaction of PD-L1 with PD-1	-	II	February 2020	NCT02968940
⁵⁷ Avelumab	-	Primary	II	September 2022	NCT03047473
⁵⁷ Avelumab	-	Recurrent	I	February 2020	NCT03341806
⁵⁷ Avelumab, ⁵⁸ Epacadostat	⁵⁸ Inhibitor of indoleamine 2,3-dioxygenase (IDO1)	Recurrent	II	April 2024	NCT03532295
⁵⁷ Avelumab, ⁵⁹ VXM01	⁵⁹ Vascular endothelial growth factor receptor 2 (VEGRF-2) vaccine	Recurrent	I/II	December 2020	NCT03750071
⁶⁰ AV-GBM-1	⁶⁰ Autologous tumor-associated antigens (TAAs)-loaded autologous dendritic cells	Primary	II	June 2023	NCT03400917
⁶¹ AZD1390	⁶¹ ATM inhibitor	-	I	April 2021	NCT03423628
⁶² AZD2014	⁶² mTOR inhibitor	Recurrent	I	December 2019	NCT02619864
⁶³ BAL101553	⁶³ Prevents tubulin polymerization and destabilizes microtubules	Primary	I	July 2022	NCT03250299
⁶³ BAL101553	-	Primary	I	July 2022	NCT03250299
⁶³ BAL101553	-	Recurrent	I/IIa	December 2019	NCT02895360, NCT02490800
⁶⁴ Bavituximab	⁶⁴ IgG3 monoclonal antibody, stimulates antibody-dependent cellular cytotoxicity	Primary	II	July 2023	NCT03139916
Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
⁶⁵ Belinostat	⁶⁵ Hydroxamic acid-type histone deacetylase inhibitor	Primary	II	June 2022	NCT02137759

⁶⁶ Bevacizumab	⁶⁶ Recombinant humanized monoclonal antibody, inhibits VEGF receptor binding	Primary	II	January 2021	NCT01149850
⁶⁶ Bevacizumab	-	Recurrent	II	September 2023	NCT01730950
⁶⁶ Bevacizumab	-	Primary	II	December 2019	NCT01740258
⁶⁶ Bevacizumab	-	Recurrent	II	December 2020	NCT01478321
⁶⁶ Bevacizumab	-	Recurrent	I	July 2020	NCT01392209
⁶⁶ Bevacizumab	-	Recurrent	II	December 2019	NCT00337207
⁶⁶ Bevacizumab	-	-	I	June 2020	NCT02285959
⁶⁶ Bevacizumab	-	Recurrent	II	March 20202	NCT02663271
⁶⁶ Bevacizumab	-	Recurrent	II	December 2019	NCT01894061
⁶⁶ Bevacizumab	-	Primary	I/II	January 2020	NCT01811498
⁶⁶ Bevacizumab	-	Recurrent	I/II	October 2021	NCT01269853
⁶⁶ Bevacizumab, ⁶⁷ Capecitabine	⁶⁷ Fluoropyrimidine carbamate, prodrug of 5-fluorouracil	Recurrent	I	November 2019	NCT02669173
⁶⁶ Bevacizumab, ⁶⁸ Keyhole Limpet Hemocyanin, Peptide Vaccine, ⁶⁹ PolyICLC	⁶⁸ Immunogenic carrier protein, increases antigenic immune responses; ⁶⁹ Synthetic complex of carboxymethylcellulose, polyinosinic-polycytidylic acid, and poly-L-lysine double-stranded RNA	Recurrent	II	June 2019	NCT02754362
⁶⁶ Bevacizumab, ¹⁵ Nivolumab	-	Recurrent	II	December 2019	NCT03452579
⁶⁶ Bevacizumab, ¹⁹ Temozolomide	-	Recurrent	III	July 2023	NCT02761070
⁷⁰ BGB-290	⁷⁰ Inhibitor of poly (ADP-ribose) polymerase (PARP)	Primary/ Recurrent	I	July 2027	NCT03749187
⁷⁰ BGB-290	-	Primary/ Recurrent	I/II	October 2021	NCT03150862
⁷⁰ BGB-290	-	Primary/ Recurrent	I	July 2027	NCT03749187
Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier

⁷¹ BGB324	⁷¹ AXL kinase inhibitor	Recurrent	I	December 2022	NCT03965494
⁷² BKM120	⁷² Pan class-1 phosphoinositide 3-kinase inhibitor	Recurrent	I/II	February 2020	NCT01349660
⁷³ BMS 986016	⁷³ Monoclonal antibody, binds to lymphocyte activation gene-3 (LAG-3) receptor	Recurrent	I	December 2020	NCT02658981
⁷³ BMS-986016, ¹⁵ Nivolumab	-	Recurrent	I	June 2021	NCT03493932
⁷⁴ BMX-001	⁷⁴ Mimetic of the human mitochondrial manganese superoxide dismutase (MnSOD)	Primary	II	September 2022	NCT02655601
⁷⁵ Bortezomib	⁷⁵ 26S proteasome inhibitor	Recurrent	Ib/II	August 2023	NCT03643549
⁷⁶ BPM31510	⁷⁶ Modulates tumor cell metabolism	Recurrent	I	January 2021	NCT03020602
⁷⁷ BRCX014	⁷⁷ Cannabidiol	Primary	I	December 2020	NCT03687034
⁷⁷ BRCX014	-	Primary	II	December 2020	NCT03607643
⁷⁸ BXQ-350	⁷⁸ Synthetic form of the human glycoprotein saposin C (SapC), activates lysosomal enzymes	Recurrent	I	January 2020	NCT02859857
⁷⁹ C134	⁷⁹ Oncolytic virus HSV-1	Recurrent	I	May 2024	NCT03657576
⁸⁰ C225-ILs-dox	⁸⁰ Doxorubicin-loaded Anti-EGFR-immunoliposomes	Recurrent	I	August 2021	NCT03603379
⁸¹ Cabozantinib	⁸¹ Tyrosine kinase inhibitor	Recurrent	II	January 2020	NCT02885324
⁸² CAN008	⁸² Antibody like CD95 receptor/Fc fusion protein	Recurrent	II	December 2021	NCT03746288
⁶⁷ Capecitabine	-	Primary	I/II	June 2021	NCT03213002
⁸³ Carboplatin	⁸³ Second generation platinum compound, induces intra-strand and inter-strand DNA cross-links	Recurrent	I/II	July 2021	NCT03672721
⁸⁴ Carboxyamidotriazole (CTO)	⁸⁴ Inhibitor of non-voltage operated Ca ²⁺ channels	Primary	I	-	NCT01107522
⁸⁵ Carboxylesterase-expressing allogeneic neural stem cells, ⁸⁶ Irinotecan hydrochloride	⁸⁵ Human fetal cell line adenovirally transduced to express a modified form of the enzyme carboxylesterase hCE1m6; ⁸⁶ Prodrug, converts into active metabolite 7-ethyl-10-hydroxy-camptothecin which inhibits topoisomerase I	Recurrent	I	March 2020	NCT02192359
Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier

⁸⁷ Carcinoembryonic Antigen-Expressing Measles Virus	⁸⁷ Oncolytic viral therapy	Recurrent	I	November 2019	NCT00390299
⁸⁸ CART-EGFRvIII T cells, ²⁵ Pembrolizumab	⁸⁸ Engineered autologous T cells with specificity for EGFRvIII	Primary	I	December 2034	NCT03726515
⁸⁹ CBL0137	⁸⁹ Curaxin-based agent that targets Facilitates Chromatin Transcription (FACT) complex	-	I	November 2019	NCT01905228
⁹⁰ CC-115	⁹⁰ mTOR and DNA-PK inhibitor	-	I	November 2019	NCT01353625
⁹¹ CC-122	⁹¹ Cereblon modulator	-	I	August 2020	NCT01421524
⁹² CC-486	⁹² Inhibits DNA methyltransferase, and thus blocks DNA methylation	-	I	December 2018	NCT02223052
⁹³ Cediranib	⁹³ Inhibitor of vascular endothelial growth factor receptor (VEGFR-1,-2,-3) tyrosine kinases	Primary	II	-	NCT01062425
⁹³ Cediranib Maleate, ⁹⁴ Olaparib	⁹⁴ Inhibitor of poly (ADP-ribose) polymerase	Recurrent	II	May 2020	NCT02974621
⁹⁵ Cemiplimab, ⁹⁶ INO-5401, ⁹⁷ INO-9012	⁹⁵ Inhibits PD-1 from binding to PD-L1; ⁹⁶ WT1/PSMA/hTERT encoding plasmid DNA; ⁹⁷ DNA plasmid encoding interleukin-12	Primary	I/II	January 2021	NCT03491683
⁹⁸ Cerebraca Wafer	⁹⁸ Biodegradable implant comprises (Z)-n-butylidenephthalide ((Z)-BP) and carboxyphenoxypropane-sebacic acid	Recurrent	I/IIa	December 2021	NCT03234595
⁹⁹ Cetuximab, ¹⁰⁰ Mannitol	⁹⁹ Anti-EGFR monoclonal antibody; ¹⁰⁰ Osmotic diuretic	Primary	I/II	June 2021	NCT02861898
⁹⁹ Cetuximab, ¹⁰⁰ Mannitol	-	Recurrent	II	May 2022	NCT02800486
¹⁰¹ Chloroquine	¹⁰¹ Chemosensitizer, inhibits autophagy	Primary	II	January 2024	NCT02432417
¹⁰¹ Chloroquine	-	Primary	I	June 2019	NCT02378532
Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
¹⁰¹ Chloroquine, ¹⁹ Temozolomide, ¹⁰² Valproic Acid	¹⁰² Anti-epileptic drug, antitumor activity is assumed to related to inhibition of nitric oxide synthesis	-	III	June 2023	NCT03243461

¹⁰³ CMV-Specific T Cells	¹⁰³ Autologous cells, CMV = Cytomegalovirus	-	I/II	June 2020	NCT02661282
Copper, ⁴⁴ Disulfiram	-	Primary	II	March 2021	NCT03363659
Copper, ⁴⁴ Disulfiram	-	Primary	I/II	April 2021	NCT02715609
Copper, ⁴⁴ Disulfiram	-	Recurrent	II/II	September 2023	NCT02678975
¹⁰⁴ Crenolanib	¹⁰⁴ Inhibitor of platelet-derived growth factor receptor (PDGFR)	Recurrent	II	April 2020	NCT02626364
²³ Cyclophosphamide, ¹⁰⁵ ERC1671, ¹⁰⁶ GM-CSF	¹⁰⁵ Cancer vaccine, induces cytotoxic T-lymphocyte (CTL) response against GBM-associated antigens; ¹⁰⁶ Recombinant agent similar to endogenous human GM-CSF, modulates proliferation and differentiation	Recurrent	II	March 2023	NCT01903330
²³ Cyclophosphamide, ¹⁰⁷ Etoposide, ¹⁰⁸ Indoximod	¹⁰⁷ Topoisomerase II inhibitor; ¹⁰⁸ Immune checkpoint inhibitor	-	I	December 2019	NCT02502708
²³ Cyclophosphamide, ¹⁰⁹ rQNestin	¹⁰⁹ Oncolytic HSV-1	Recurrent	I	July 2022	NCT03152318
¹¹⁰ Dabrafenib, ¹¹¹ Trametinib	¹¹⁰ B-raf (BRAF) protein inhibitor; ¹¹¹ Inhibitor of mitogen-activated protein kinase (MEK MAPK/ERK kinase)	Primary	II	June 2022	NCT03919071
¹¹⁰ Dabrafenib, ¹¹¹ Trametinib	-	Recurrent	II	September 2024	NCT02684058
¹¹² Dasatinib	¹¹² Inhibitor of SRC-family protein-tyrosine kinases	Primary	I/II	-	NCT00869401
¹¹³ Dendritic Cell Vaccination	¹¹³ Immunotherapy (therapeutic autologous dendritic cells)	Primary	II	December 2023	NCT03927222
¹¹³ Dendritic Cell Vaccination	-	-	I	November 2023	NCT01808820
¹¹³ Dendritic Cell Vaccination	-	Primary/ Recurrent	I	January 2021	NCT02010606
Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
¹¹³ Dendritic Cell Vaccination	-	Recurrent	I/II	January 2022	NCT03879512
¹¹³ Dendritic Cell Vaccination	-	Primary	II	June 2020	NCT02366728

¹¹³ Dendritic Cell Vaccine	-	Primary	I/II	December 2022	NCT02649582
¹¹³ Dendritic Cells	-	Primary	II	June 2024	NCT02465268
¹¹³ Dendritic Cells, ¹¹⁴ Lymphocytes, ¹¹⁵ Tetanus Toxoid	¹¹⁴ Immunotherapy (therapeutic autologous lymphocytes); ¹¹⁵ Stimulates the production of antitoxin antibodies	Primary	I	January 2020	NCT00639639
¹¹³ Dendritic Cells, ¹⁵ Nivolumab	-	Recurrent	II	June 2022	NCT03014804
¹¹³ Dendritic Cells, ¹¹⁵ Tetanus toxoid	-	Primary	I	August 2020	NCT03615404
¹¹³ Dendritic Cells	-	-	II/II	May 2023	NCT03548571
¹¹³ Dendritic Cells	-	Primary	II	June 2023	NCT03395587
⁴⁴ Disulfiram, Copper	-	Primary	II	January 2020	NCT01777919
¹¹⁶ DNX-2401	¹¹⁶ Oncolytic adenovirus serotype 5 strain	Recurrent	I	February 2020	NCT03896568
¹¹⁶ DNX-2401, ²⁵ Pembrolizumab	-	Recurrent	II	June 2021	NCT02798406
¹¹⁷ DNX-2440	¹¹⁷ OX40L expressing oncolytic adenovirus	Recurrent	I	October 2022	NCT03714334
¹¹⁸ Doxorubicin	¹¹⁸ Intercalates between base pairs, inhibits topoisomerase II, and thus prevents DNA replication	-	II	July 2020	NCT02758366
¹¹⁸ Doxorubicin, ¹⁰⁷ Etoposide	-	-	I	October 2020	NCT02372409
¹¹⁹ DSP-7888	¹¹⁹ Wilms tumor gene 1 (WT1) protein derived peptide vaccine	Recurrent	I/II	April 2020	NCT02750891
¹¹⁹ DSP-7888	-	Recurrent	II	October 2020	NCT03149003

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¹²⁰ Durvalumab	¹²⁰ Monoclonal antibody, blocks PD-L1 from binding to PD-1	Recurrent	I/II	July 2020	NCT02866747
¹²¹ EGFR BATs	¹²¹ EGFRBi-armed activated T cells, induces T cell mediated cytotoxicity	Primary	I	December 2020	NCT03344250
¹²² EGFR(V)-EDV-Dox	¹²² Doxorubicin-loaded EGFR-targeting nanocells, inhibits topoisomerase II, and thus inhibits DNA replication	Recurrent	I	June 2020	NCT02766699

⁸⁸ EGFRvIII CAR T Cells	-	Primary	I	September 2019	NCT02664363
⁸⁸ EGFRvIII-CAR-T Cells	-	Recurrent	I	December 2022	NCT03283631
¹²³ Enzastaurin	¹²³ Inhibitor of protein kinase C beta	Primary	IIb	December 2022	NCT03776071
¹²⁴ Epitinib Succinate (HMPL-813)	¹²⁴ Inhibitor of epidermal growth factor receptor	-	I	August 2020	NCT03231501
¹²⁵ Erbix, ⁶⁶ Bevacizumab	¹²⁵ Inhibitor of epidermal growth factor receptor	Recurrent	I/II	January 2025	NCT01884740
¹²⁶ Everolimus (RAD001)	¹²⁶ mTOR inhibitor	Primary	I/II	-	NCT01062399
¹²⁶ Everolimus (RAD001)	-	Primary	I/II	-	NCT00553150
¹²⁶ Everolimus, ¹²⁷ Ribociclib	¹²⁷ Inhibitor of cyclin-dependent kinase (CDK)	Recurrent	I	December 2020	NCT03834740
¹²⁶ Everolimus, ¹²⁷ Ribociclib	-	Primary	I	January 2022	NCT03355794
¹²⁶ Everolimus, ¹²⁸ Sorafenib	¹²⁸ Inhibitor of RAF kinase and VEGFR-2/PDGFR-beta signaling cascade	Recurrent	I/II	July 2020	NCT01434602
¹²⁹ Filgrastim, ¹³⁰ Gemcitabine, ¹²⁷ Ribociclib, ¹³¹ Sonidegib, ¹³² Trametinib	¹²⁹ Agonist of G-CSF receptor; ¹³⁰ Inhibitor of ribonucleotide reductase; ¹³¹ Inhibitor of hedgehog (Hh)-ligand cell surface receptor Smo; ¹³² Inhibitor of mitogen-activated protein kinase kinase	Recurrent	I	March 2025	NCT03434262
¹³³ Fimepinostat	¹³³ Inhibitor of phosphoinositide 3-kinase (PIK) class I and pan histone deacetylase (HDAC)	Recurrent	I	June 2027	NCT03893487

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² Flucytosine, ¹³⁴ Leucovorin Calcium, ¹³⁵ Neural Stem Cells	¹³⁴ Active metabolite of folic acid, counteracts the toxic effect of folate antagonist-type chemotherapeutic drugs; ¹³⁵ Genetically modified E. coli cytosine deaminase (CD)-expressing neural stem cells	Recurrent	I	June 2019	NCT02015819
¹³⁶ FT-2102	¹³⁶ IDH-1 inhibitor	-	I	April 2022	NCT03684811
¹³⁷ GC1118	¹³⁷ Anti-EGFR monoclonal antibody	Recurrent	II	July 2020	NCT03618667
¹³⁸ GDC-0084	¹³⁸ Phosphatidylinositol 3-kinase (PI3K) inhibitor	Primary	II	December 2020	NCT03522298
¹³⁸ GDC-0084	-	Primary	I	June 2024	NCT03696355

¹³⁹ Glasdegib (PF-04449913)	¹³⁹ Smoothened (SMO) receptor inhibitor	Primary	Ib/II	March 2021	NCT03466450
¹⁴⁰ gp96	¹⁴⁰ Autologous heat shock protein	Primary	II	August 2023	NCT03650257
¹⁴¹ GS5745	¹⁴¹ Anti-MMP-9 monoclonal antibody	Recurrent	I	January 2022	NCT03631836
¹⁴¹ GS5745	-	Recurrent	I	January 2022	NCT03631836
¹⁴² GX-I7	¹⁴² Recombinant human IL-7-hybrid Fc	-	I/II	May 2020	NCT03619239
¹⁴³ hrBMP4	¹⁴³ Recombinant human bone morphogenetic protein 4, binds to BMP receptors (BMPRs)	Recurrent	I	August 2019	NCT02869243
¹⁴⁴ HSPPC-96	¹⁴⁴ Autologous cancer vaccine derived from tumor-specific heat shock protein gp96	Primary/ Recurrent	I	May 2020	NCT02722512
¹⁴⁴ HSPPC-96, ²⁵ Pembrolizumab	-	Primary	II	January 2024	NCT03018288
¹⁴⁵ G207	¹⁴⁵ Recombinant HSV-1, inhibits UL39 and viral ribonucleotide reductase	Recurrent	I	July 2023	NCT03911388
¹⁴⁵ G207	-	Recurrent	I	April 2020	NCT02457845
¹⁴⁶ Hydroxyurea	¹⁴⁶ Selective inhibitor of ribonucleoside diphosphate reductase	Recurrent	I	June 2020	NCT03463733
¹⁴⁷ Ibrutinib	¹⁴⁷ BTK inhibitor	Primary	I	December 2019	NCT03535350
¹⁴⁸ IDH305	¹⁴⁸ IDH1 (R132) inhibitor	-	I	June 2020	NCT02381886

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¹⁴⁹ IMMU-132	¹⁴⁹ Antibody-drug conjugate containing humanized monoclonal antibody, hRS7, against tumor-associated calcium signal transducer 2 and linked to the active metabolite of Irinotecan	-	I/II	June 2020	NCT01631552
¹⁵⁰ INC280	¹⁵⁰ Inhibitor of the proto-oncogene c-Met (hepatocyte growth factor receptor)	Recurrent	Ib	November 2020	NCT02386826
¹⁵¹ INCB024360, ¹⁵² Ipilimumab,	¹⁵¹ Inhibitor of indoleamine 2,3-dioxygenase (IDO1); ¹⁵² Recombinant human monoclonal antibody, inhibitor of	Recurrent	I	February 2024	NCT03707457

¹⁵³ MK-4166, ¹⁵ Nivolumab	CTLA4-mediated downregulation of T-cell activation; ¹⁵³ Anti-human glucocorticoid-induced tumor necrosis factor receptor (GITR) agonistic monoclonal antibody				
¹⁵⁴ INT230-6	¹⁵⁴ Formulation of cisplatin, vinblastine and a cell penetration enhancer	Recurrent	I	August 2020	NCT03058289
¹⁵⁵ Lonafarnib	¹⁵⁵ Inhibitor of farnesyl transferase	Recurrent	I	December 2020	NCT00102648
¹⁵² Ipilimumab, ¹⁵ Nivolumab	-	Primary	I	-	NCT02311920
¹⁵² Ipilimumab, ¹⁵ Nivolumab	-	Recurrent	II	August 2021	NCT03430791
¹⁵² Ipilimumab, ¹⁵ Nivolumab	-	Recurrent	I	November 2019	NCT03233152
¹⁵² Ipilimumab, ¹⁵ Nivolumab	-	Primary	II	January 2020	NCT03367715
⁸⁶ Irinotecan	-	Recurrent	I/II	July 2020	NCT03119064
¹⁵⁶ KB004	¹⁵⁶ Anti ephrin receptor A3 (EphA3) monoclonal antibody	Recurrent	I	April 2021	NCT03374943
¹⁵⁷ Lapatinib	¹⁵⁷ Orally-active quinazoline, reversibly blocks phosphorylation of the epidermal growth factor receptor (EGFR), ErbB2, and the Erk-1 and-2 and AKT kinases	Primary	II	December 2022	NCT01591577

Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
¹⁵⁸ Lapatinib Ditosylate	¹⁵⁸ Ditosylate salt of lapatinib	Recurrent	I	December 2019	NCT02101905
¹⁵⁹ LB-100	¹⁵⁹ Protein phosphatase 2A inhibitor	Recurrent	II	August 2021	NCT03027388
¹⁶⁰ Lenvatinib, ²⁵ Pembrolizumab	¹⁶⁰ Inhibitor of vascular endothelial growth factor receptor 2 tyrosine kinase	-	II	April 2022	NCT03797326
¹⁶¹ Levetiracetam	¹⁶¹ Anti-epileptic drug, inhibits burst firing without affecting normal neuronal excitability	Primary	II	June 2022	NCT02815410
¹⁶² Lomustine	¹⁶² Nitrosourea compound, alkylates and crosslinks DNA	Recurrent	II	November 2021	NCT03022578
¹⁶² Lomustine, ¹⁶³ Sunitinib	¹⁶³ Inhibits tyrosine kinase activities of vascular endothelial growth factor receptor 2, platelet-derived growth factor receptor b, and c-kit	Recurrent	II/III	January 2020	NCT03025893
¹⁶² Lomustine, ¹⁶⁴ USL311	¹⁶⁴ Inhibitor of C-X-C chemokine receptor type 4 (CXCR4)	Recurrent	I/II	September 2022	NCT02765165
¹⁶⁵ LOXO-195	¹⁶⁵ Tyrosine receptor kinase (TRK) inhibitor	-	I/II	February 2022	NCT03215511

¹⁶⁶ LY2157299	¹⁶⁶ Inhibitor of the tyrosine kinase transforming growth factor-beta (TGF-β) receptor type 1	Recurrent	II	December 2019	NCT01582269
¹⁶⁷ M032	¹⁶⁷ Genetically engineered HSV-1 expressing IL-12	Recurrent	I	September 2020	NCT02062827
¹⁶⁸ Marizomib	¹⁶⁸ Inhibitor of the 20S catalytic core subunit of the proteasome	Primary	I	May 2020	NCT02903069
¹⁶⁸ Marizomib	-	Primary	III	July 2023	NCT03345095
¹⁶⁸ Marizomib	-	-	I/II	February 2020	NCT02330562
¹⁶⁹ MBG453	¹⁶⁹ Immunotherapy	Recurrent	I	June 2023	NCT03961971
¹⁷⁰ MDNA55	¹⁷⁰ IL4-Pseudomonas exotoxin fusion protein, binds to IL-4 receptors on tumor cell surface	Recurrent	II	March 2020	NCT02858895
¹⁷¹ Mebendazole	¹⁷¹ Anthelmintic, inhibits the formation cytoplasmic microtubules in helminths	Primary	I	September 2020	NCT01729260
¹⁷¹ Mebendazole	-	-	I	April 2020	NCT01837862
¹⁷¹ Mebendazole	-	Recurrent	I	June 2021	NCT02644291

Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
¹⁷² MEDI4736	¹⁷² Fc optimized monoclonal antibody, prevents PD-L1 from binding to PD-1	Primary/ Recurrent	II	December 2019	NCT02336165
¹⁷³ Memantine, ¹⁷⁴ Mefloquine, ¹⁷⁵ Metformin	¹⁷³ N-methyl-D-aspartate receptor antagonist; ¹⁷⁴ Chemosensitizer, accumulates in lysosome and disrupts lysosomal function, and assumed to inhibit autophagocytosis; ¹⁷⁵ Antihyperglycemic, inhibits complex I (NADPH: ubiquinon oxidoreductase) of the mitochondrial respiratory chain	-	I	September 2022	NCT01430351
¹⁷⁵ Metformin	-	Recurrent	II	December 2019	NCT03243851
¹⁷⁵ Metformin	-	Primary	II	December 2021	NCT02780024
¹⁷⁵ Metformin	-	Recurrent	I	July 2018	NCT02149459
¹⁷⁶ MK-3475	¹⁷⁶ Humanized monoclonal antibody, inhibits PD-1 activation by its ligands	Recurrent	I	August 2021	NCT02852655
¹⁷⁷ MN-166	¹⁷⁷ Inhibitor of cyclic nucleotide phosphodiesterase	Recurrent	I/II	December 2020	NCT03782415

¹⁷⁸ NEO100	¹⁷⁸ Inhibitor of farnesyl transferase and geranylgeranyl transferase	Recurrent	I/II	October 2020	NCT02704858
¹⁷⁹ Neural Stem Cell Based Virotherapy	¹⁷⁹ Neural stem cells loaded with an oncolytic adenovirus	Primary	I	April 2020	NCT03072134
¹⁵ Nivolumab	-	Primary	III	August 2023	NCT02667587
¹⁵ Nivolumab	-	Recurrent	II	November 2021	NCT03743662
¹⁵ Nivolumab	-	Recurrent	II	August 2022	NCT03890952
¹⁵ Nivolumab	-	Primary	III	September 2020	NCT02617589
¹⁵ Nivolumab	-	-	II	August 2025	NCT03718767
¹⁵ Nivolumab, ⁵⁸ Epacadostat	-	-	II	October 2020	NCT02327078
¹⁵ Nivolumab, ¹⁵² Ipilimumab	-	Recurrent	III	October 2019	NCT02017717

Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
¹⁸⁰ NK-92/5.28.z Cells	¹⁸⁰ Genetically modified anti-HER2-CAR-CD28zeta-expressing allogeneic natural killer cells, binds to HER2 expressed on tumor cells	Recurrent	I	August 2020	NCT03383978
¹⁸¹ NU-0129	¹⁸¹ Spherical nucleic acid nanoparticle, inhibitor of Bcl-2-like protein 12 (BCL2L12) gene	Recurrent	I	July 2022	NCT03020017
¹⁸² NVX-108	¹⁸² Radiosensitizer, increases tumor oxygenation	Primary	II	December 2023	NCT03862430
¹⁸³ OKN-007	¹⁸³ Assumed to inhibit sulfatase-2 (SULF2)	Recurrent	I/II	December 2020	NCT03649464
¹⁸³ OKN-007	-	Primary	I	June 2025	NCT03587038
⁹³ Olaparib	-	-	II	July 2020	NCT03212274
¹⁸⁴ ONC201	¹⁸⁴ Inhibitor of the serine/threonine protein kinase Akt (protein kinase B) and extracellular signal-regulated kinase (ERK)	Recurrent	II	December 2020	NCT02525692
¹⁸⁵ PAC-1	¹⁸⁵ Procaspase activating compound-1	-	I	June 2020	NCT03332355
¹⁸⁶ Pazopanib	¹⁸⁶ Selective inhibitor of vascular endothelial growth factor receptors (VEGFR)-1,-2 and -3, c-kit and platelet derived growth factor receptor (PDGF-R)	Primary	I/II	March 2021	NCT02331498
²⁵ Pembrolizumab	-	Primary	I	November 2020	NCT02530502

²⁵ Pembrolizumab	-	Recurrent	II	November 2019	NCT02337686
²⁵ Pembrolizumab	-	Recurrent	II	February 2021	NCT03661723
²⁵ Pembrolizumab	-	Primary	II	February 2023	NCT03405792
²⁵ Pembrolizumab	-	Recurrent	I/II	February 2020	NCT03277638
²⁵ Pembrolizumab, ¹⁸⁷ TTAC-0001	¹⁸⁷ Human monoclonal antibody, prevents vascular endothelial growth factor receptor 2 from binding to its ligand VEGF	Recurrent	Ib	April 2020	NCT03722342
²⁵ Pembrolizumab, ¹⁸⁸ Vorinostat	¹⁸⁸ Inhibitor of histone deacetylase	Primary	I	April 2022	NCT03426891
¹⁸⁹ Pemetrexed Disodium	¹⁸⁹ Inhibitor of thymidylate synthase	Recurrent	II	December 2020	NCT00276783
¹⁹⁰ Perifosine, ³³ Temsirolimus	¹⁹⁰ Alkyl-phosphocholine compound, involved in cell differentiation and inhibition of cell growth, also inhibits anti-apoptotic MAPK pathway	Recurrent	I	August 2019	NCT02238496
Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
¹⁹¹ Personalized cellular Vaccine	¹⁹¹ Personalized antigen pulsed DCs	Recurrent	I	September 2020	NCT02808364
¹⁹² Plerixafor	¹⁹² Inhibits the binding of stromal cell-derived factor (SDF-1alpha) to the cellular receptor CXCR4	Primary	II	January 2027	NCT03746080
¹⁹³ PLX3397	¹⁹³ Receptor tyrosine kinase (RTK) inhibitor of KIT, CSF1R and FLT3	Primary	Ib/II	October 2019	NCT01790503
⁶⁹ Poly-ICLC	-	Primary	I	May 2021	NCT03223103
¹⁹⁴ PT2385	¹⁹⁴ Inhibitor of hypoxia inducible factor (HIF)-2alpha	Recurrent	II	December 2019	NCT03216499
¹⁹⁵ PT2977	¹⁹⁵ Inhibitor of hypoxia inducible factor (HIF)-2alpha	-	I	June 2020	NCT02974738
⁵⁶ PVSRIPO	-	Recurrent	Ib	July 2021	NCT03043391
⁵⁶ PVSRIPO	-	Recurrent	II	May 2023	NCT02986178
⁵⁶ PVSRIPO	-	Recurrent	I	June 2021	NCT01491893
¹⁹⁶ Ramipril	¹⁹⁶ Inhibitor of nonsulfhydryl angiotensin converting enzyme (ACE)	-	II	August 2021	NCT03475186

¹⁹⁷ Regorafenib	¹⁹⁷ Inhibitor of vascular endothelial growth factor receptors (VEGFRs) 2 and , and Ret, Kit, PDGFR and Raf kinases	Recurrent	II	October 2018	NCT02926222
¹⁹⁸ Rhenium	¹⁹⁸ Liposomal rhenium 186, releases radiation, which kills tumor cells	Recurrent	I	January 2020	NCT01906385
¹²⁷ Ribociclib (LEE011)	-	Recurrent	I	January 2020	NCT02345824
¹⁹⁹ Rovalpituzumab Tesirine	¹⁹⁹ Antibody (SC16)-drug (D6.5) conjugate	-	I/II	September 2020	NCT02709889
²⁰⁰ RRx-001	²⁰⁰ Radiosensitizer	Primary	I	January 2020	NCT02871843
²⁰¹ Ruxolitinib	²⁰¹ Inhibitor of Janus-associated kinase (JAK)	Primary	I	December 2020	NCT03514069
²⁰² Sapanisertib	²⁰² Inhibitor of raptor-mTOR and rictor-mTOR	Recurrent	I	December 2019	NCT02142803
²⁰³ Selinexor	²⁰³ Inhibitor of CRM1 (chromosome region maintenance 1 protein)	Recurrent	II	December 2019	NCT01986348
²⁰³ Selinexor	-	Recurrent	I	March 2021	NCT02323880
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Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
²⁰⁴ Sildenafil Citrate, ¹²⁸ Sorafenib tosylate, ¹⁰² Valproic Acid	²⁰⁴ Selective inhibitor of cyclic guanosine monophosphate (cGMP)-specific type 5 phosphodiesterase	Recurrent	II	June 2021	NCT01817751
²⁰⁵ Siroquinone (JP001)	²⁰⁵ Siroquinone: Rapamycin (mTOR inhibitor) + Hydroxychloroquine sulfate	Primary	II/III	October 2023	NCT03008148
²⁰⁶ Solriamfetol	²⁰⁶ Wakefulness promoting drug, improves sleep, memory, fatigue, mood, or quality of life	Primary	II	January 2022	NCT03868943
²⁰⁷ Sym004	²⁰⁷ Anti-EGFR monoclonal antibody mixture, inhibits EGFR dependent tumor cell proliferation and metastasis	Recurrent	II	May 2020	NCT02540161
²⁰⁸ T Cells (genetically modified)	²⁰⁸ IL13R α 2-specific, hinge optimized, 41BB-costimulatory CAR/truncated CD19-expressing autologous T lymphocytes	Recurrent	I	May 2020	NCT02208362
²⁰⁹ Temferon	²⁰⁹ Immunotherapy consists of autologous CD34+ enriched hematopoietic stem and progenitor cells	-	I/IIa	December 2022	NCT03866109
¹⁹ Temozolomide	-	-	III	April 2021	NCT03633552

¹⁹ Temozolomide (intensified)	-	Primary	III	May 2023	NCT03663725
²¹⁰ Tesevatinib	²¹⁰ Receptor tyrosine kinase (RTK) inhibitor	Recurrent	II	December 2019	NCT02844439
²¹¹ TG02	²¹¹ Inhibitor of cyclin dependent kinase (CDK) subtypes 1, 2, 7 and 9, Janus associated kinase 2 (JAK2), FMS related tyrosine kinase 3 (FLT3, FLK2, STK1)	Recurrent	I/II	August 2022	NCT02942264
²¹¹ TG02	-	Primary/ Recurrent	I	August 2020	NCT03224104
²¹² TH-302	²¹² Induces intra- and inter-strand DNA crosslinks	-	II	July 2019	NCT02342379
²¹³ TIL (Tumor-infiltrating T Lymphocyte)	²¹³ Transgenic cells	-	I	June 2020	NCT03347097

Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
²¹⁴ Tinostamustine	²¹⁴ Alkylating histone-deacetylase inhibitor	Primary	I	October 2020	NCT03452930
²¹⁵ TN-TC11G (THC+CBD)	²¹⁵ THC = Δ^9 -tetrahydrocannabinol, CBD = Cannabidiol	Primary	Ib	June 2020	NCT03529448
²¹⁶ Toca 511, ²¹⁷ Toca FC	²¹⁶ Replication competent retroviral vector (gene therapy); ²¹⁷ An extended release oral tablet that contains flucytosine (prodrug), inhibits thymidylate synthetase	Recurrent	II/III	March 2023	NCT02414165
²¹⁸ Topotecan	²¹⁸ Selectively stabilizes topoisomerase I-DNA covalent complexes, inhibiting relegation of topoisomerase I-mediated single-strand DNA breaks	-	II	December 2019	NCT01004874
²¹⁸ Topotecan, ²¹⁹ Pazopanib	²¹⁹ Selective inhibitor of vascular endothelial growth factor receptors (VEGFR)-1, -2 and -3, c-kit and platelet derived growth factor receptor (PDGF-R)	Recurrent	II	September 2020	NCT01931098
²²⁰ Trans Sodium Crocetinate	²²⁰ Antihypoxic and radiosensitizing agent	Primary	III	June 2022	NCT03393000
²²¹ Trebananib	²²¹ Angiopoietin (Ang) 1 and 2 neutralizing peptibody	Recurrent	II	-	NCT01609790
²²² Tremelimumab, ¹²⁰ Durvalumab	²²² Human immunoglobulin (Ig) G2 monoclonal antibody, inhibits cytotoxic T-lymphocyte associated protein 4 (CTLA4) mediated downregulation of T-cell activation	Recurrent	II	June 2020	NCT02794883

¹⁸⁷ TTAC-0001	-	Recurrent	II	November 2020	NCT03856099
²²³ VAL-083	²²³ DNA alkylating and cross-linking agent	Recurrent	II	June 2021	NCT02717962
²²³ VAL-083	-	Primary	II	June 2020	NCT03050736
¹⁰² Valproic Acid, ⁶⁶ Bevacizumab	-	Primary	II	May 2019	NCT00879437
²²⁴ VBI-1901	²²⁴ Cancer vaccine that exerts a cytotoxic T-lymphocyte (CTL) immune response against CMV gB and pp65 expressing tumor cells	Recurrent	I	December 2019	NCT03382977
Therapeutic Agent (s) under Investigation	Description/Mechanism of Action	Disease Type	Clinical Trial Phase	Estimated Completion Date	Clinical Trial Identifier
²²⁵ V-Boost	²²⁵ Oral tablet which contains hydrolyzed GBM antigens and alloantigens	Recurrent	II	June 2020	NCT03916757
¹⁶ Veledimex, ¹⁴ Ad-RTS-hIL-12	-	Recurrent	I	June 2021	NCT03679754
²²⁶ Veliparib	²²⁶ Inhibitor of poly (ADP-ribose) polymerase (PARP) -1 and -2	Primary	II/III	June 2022	NCT02152982
²²⁶ Veliparib	-	Primary	II	October 2024	NCT03581292
¹⁸⁸ Vorinostat	-	Primary	I/II	-	NCT00731731
¹⁸⁸ Vorinostat	-	Primary	I/II	November 2020	NCT01189266
¹⁸⁸ Vorinostat	-	-	I	-	NCT00268385
¹⁸⁸ Vorinostat, ²²⁷ Isotretinoin	²²⁷ Agonist of nuclear retinoic acid receptors (RARs)	Recurrent	I/II	November 2019	NCT00555399
²²⁸ WP1066	²²⁸ Inhibitor of Janus-associated Kinase 2 (JAK2)	Recurrent	I	July 2021	NCT01904123
²²⁹ ZSP1602	²²⁹ SMO protein inhibitor	-	I	December 2020	NCT03734913
²³⁰ α -IFN	²³⁰ Immunotherapeutic agent	Primary	III	December 2019	NCT01765088
²³¹ β -elemene	²³¹ Induces apoptosis and cell cycle arrest	Primary	III	May 2023	NCT02629757



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