Claims

1. A CD7-targeting humanized antibody or antigen-binding fragment thereof, comprising: the amino acid sequence of the heavy chain variable region as shown in SEQ ID NO: 1 and the amino acid sequence of the light chain variable region as shown in SEQ ID NO: 2;

or, the amino acid sequence of the heavy chain variable region as shown in SEQ ID NO: 1 and the amino acid sequence of the light chain variable region as shown in SEQ ID NO: 30;

or, the amino acid sequence of the heavy chain variable region as shown in SEQ ID NO: 28 and the amino acid sequence of the light chain variable region as shown in SEQ ID NO: 30.

2. The humanized antibody or antigen-binding fragment thereof according to claim 1, which is a scFv antibody, a $sc(Fv)_2$ antibody, or a $[sc(Fv)_2]_2$ antibody.

3. The humanized antibody or antigen-binding fragment thereof according to claim 1 or 2, which is the scFv antibody with the amino acid sequence as shown in SEQ ID NO: 3;

or, which is the scFv antibody with the amino acid sequence as shown in SEQ ID NO: 35;

or, which is the scFv antibody with the amino acid sequence as shown in SEQ ID NO: 36.

4. An isolated nucleic acid molecule comprising a nucleotide sequence encoding the humanized antibody or antigen-binding fragment thereof according to any one of claims 1-3;

wherein the nucleotide sequence encoding the amino acid sequences of the heavy chain variable region as shown in SEQ ID NO: 1, is shown in SEQ ID NO: 4;

and/or, the nucleotide sequence encoding the amino acid sequences of the light chain variable region as shown in SEQ ID NO: 2, is shown in SEQ ID NO: 5;

and/or, the nucleotide sequence encoding the amino acid sequences of the heavy chain variable region as shown in SEQ ID NO: 28, is shown in SEQ ID NO: 37;

and/or, the nucleotide sequence encoding the amino acid sequences of the light chain variable region as shown in SEQ ID NO: 30, is shown in SEQ ID NO: 38.

5. A cell comprising the humanized antibody or antigen-binding fragment thereof according to any one of claims 1-3, or the isolated nucleic acid molecule according to claim 4.

6. A pharmaceutical composition comprising the humanized antibody or antigen-binding fragment thereof according to any one of claims 1-3, the isolated nucleic acid molecule according to claim 4, or the cell according to claim 5, and a pharmaceutically acceptable adjuvant.

7. A CD7-targeting chimeric antigen receptor, comprising a CD7-targeting extracellular antigen recognition domain, a hinge region, a transmembrane region, and an intracellular domain, wherein the CD7-targeting extracellular antigen recognition domain comprises:

the amino acid sequence of the heavy chain variable region as shown in SEQ ID NO: 1 and the amino acid sequence of the light chain variable region as shown in SEQ ID NO: 2;

or, the amino acid sequence of the heavy chain variable region as shown in SEQ ID NO: 1 and the amino acid sequence of the light chain variable region as shown in SEQ ID NO: 30;

or, the amino acid sequence of the heavy chain variable region as shown in SEQ ID NO: 28 and the amino acid sequence of the light chain variable region as shown in SEQ ID NO: 30.

8. The chimeric antigen receptor according to claim 7, wherein the extracellular antigen recognition domain comprises any one structure selected from the group consisting of: (the amino acid sequence as shown in SEQ ID NO: 1)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 2), (the amino acid sequence as shown in SEQ ID NO: 2)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 1), (the amino acid sequence as shown in SEQ ID NO: 1)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 30), (the amino acid sequence as shown in SEQ ID NO: 30)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 1), (the amino acid sequence as shown in SEQ ID NO: 28)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 30), (the amino acid sequence as shown in SEQ ID NO: 30)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 28);

optionally, the extracellular antigen recognition domain comprises any one structure selected from the group consisting of: (the amino acid sequence as shown in SEQ ID NO: 2)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 1), (the

amino acid sequence as shown in SEQ ID NO: 30)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 1), (the amino acid sequence as shown in SEQ ID NO: 30)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 28);

further optionally, the extracellular antigen recognition domain is any one structure selected from the group consisting of: (the amino acid sequence as shown in SEQ ID NO: 2)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 1), (the amino acid sequence as shown in SEQ ID NO: 30)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 1), (the amino acid sequence as shown in SEQ ID NO: 30)-(a linker sequence)-(the amino acid sequence as shown in SEQ ID NO: 28).

9. The chimeric antigen receptor according to claim 8, wherein the linker sequence is selected from one or more of the following sequences: SEQ ID NO: 6, SEQ ID NO: 7 and SEQ ID NO: 8.

10. The chimeric antigen receptor according to claim 9, wherein the extracellular antigen recognition domain comprises: the scFv antibody with the amino acid sequence as shown in SEQ ID NO: 3, or the scFv antibody with the amino acid sequence as shown in SEQ ID NO: 35, or the scFv antibody with the amino acid sequence as shown in SEQ ID NO: 36;

optionally, the amino acid sequence of the extracellular antigen recognition domain is shown in SEQ ID NO: 3, or is shown in SEQ ID NO: 35, or is shown in SEQ ID NO: 36.

11. The chimeric antigen receptor according to any one of claims 7-10, wherein the hinge region is derived from one or more of IgG1, IgG4, CD4, CD7, CD28, CD84, CD8α; optionally, the amino acid sequence of the hinge region is derived from CD8α; further optionally, the amino acid sequence of the hinge region comprises the amino acid sequence as shown in SEQ ID NO: 9.

12. The chimeric antigen receptor according to any one of claims 7-10, wherein the transmembrane region is derived from one or more of CD3, CD4, CD7, CD8α, CD28, CD80, CD86, CD88, 4-1BB, CD152, OX40, Fc70; optionally, the amino acid sequence of the transmembrane region is derived from CD8α; further optionally, the amino acid sequence of the transmembrane region comprises the amino acid sequence as shown in SEQ ID NO: 10.

13. The chimeric antigen receptor according to any one of claims 7-10, wherein the intracellular domain comprises an intracellular signal transduction region; optionally, the intracellular domain further comprises a costimulatory signal transduction region;

optionally, the intracellular signal transduction region is derived from one or more of CD3ζ, CD3γ, CD3δ, CD3ε, CD5, CD22, CD79a, CD79b, FcRγ, FcRβ, CD66d, DAP10,

DAP12, Syk; optionally, the intracellular signal transduction region is derived from CD3ζ; further optionally, the amino acid sequence of the intracellular signal transduction region comprises the amino acid sequence as shown in SEQ ID NO: 11;

further optionally, the costimulatory signal transduction region is derived from one, two, or more of CD2, CD3, CD7, CD27, CD28, CD30, CD40, CD83, CD244, 4-1BB, OX40, LFA-1, ICOS, LIGHT, NKG2C, NKG2D, DAP10, B7-H3, MyD88; optionally, the costimulatory signal transduction region is derived from CD28 or 4-1BB; further optionally, the amino acid sequence of the costimulatory signal transduction region comprises the amino acid sequence as shown in SEQ ID NO: 12.

14. The chimeric antigen receptor according to any one of claims 7-10, which further comprises a guiding peptide located at the N-terminus of the amino acid sequence of the chimeric antigen receptor; optionally, the guiding peptide is derived from CD8α; further optionally, the amino acid sequence of the guiding peptide comprises the amino acid sequence as shown in SEQ ID NO: 13.

15. The chimeric antigen receptor according to any one of claims 7-10, wherein the chimeric antigen receptor comprises any one of the following sequences: the amino acid sequence as shown in SEQ ID NO: 14, or the amino acid sequence as shown in SEQ ID NO: 18; or the amino acid sequence as shown in SEQ ID NO: 19;

optionally, the amino acid sequence of the chimeric antigen receptor is shown in SEQ ID NO: 14, or is shown in SEQ ID NO: 18, or is shown in SEQ ID NO: 19.

16. An isolated nucleic acid molecule comprising a nucleotide sequence encoding the chimeric antigen receptor according to any one of claims 7-10;

optionally, the nucleotide sequence comprises:

a nucleotide sequence encoding the amino acid sequence of the heavy chain variable region as shown in SEQ ID NO: 1, which is shown in SEQ ID NO: 4; and a nucleotide sequence encoding the amino acid sequence of the light chain variable region as shown in SEQ ID NO: 2, which is shown in SEQ ID NO: 5;

or, a nucleotide sequence encoding the amino acid sequence of the heavy chain variable region as shown in SEQ ID NO: 1, which is shown in SEQ ID NO: 4; and a nucleotide sequence encoding the amino acid sequence of the light chain variable region as shown in SEQ ID NO: 30, which is shown in SEQ ID NO: 38;

or, a nucleotide sequence encoding the amino acid sequence of the heavy chain variable region as shown in SEQ ID NO: 28, which is shown in SEQ ID NO: 37; and a nucleotide sequence encoding the amino acid sequence of the light chain variable region as shown in SEQ ID NO: 30, which is shown in SEQ ID NO: 38; or

optionally, the nucleotide sequence comprises:

a nucleotide sequence encoding the amino acid sequence as shown in SEQ ID NO: 14, which is shown in SEQ ID NO: 15;

or, a nucleotide sequence encoding the amino acid sequence as shown in SEQ ID NO: 18, which is shown in SEQ ID NO: 39;

or, a nucleotide sequence encoding the amino acid sequence as shown in SEQ ID NO: 19, which is shown in SEQ ID NO: 40.

17. An engineered immune effector cell comprising the chimeric antigen receptor according to any one of claims 7-15, the isolated nucleic acid molecule according to claim 16;

optionally, the engineered immune effector cell is selected from T lymphocyte; further optionally, the source of the T lymphocyte is an autologous T lymphocyte or allogeneic T lymphocyte; even further optionally, the allogeneic T lymphocyte comprises gene-edited *CD7/TRAC* double-negative cell;

most optionally, the T lymphocyte is an αβT lymphocyte or a γδT lymphocyte.

18. A pharmaceutical composition comprising the engineered immune effector cell according to claim 17, and a pharmaceutically acceptable adjuvant;

optionally, the pharmaceutically acceptable adjuvant includes a protective agent;

further optionally, the pharmaceutically acceptable adjuvant includes a cell cryopreservation solution.

19. A method for preparing the engineered immune effector cell, including the following steps: introducing a nucleotide sequence encoding the chimeric antigen receptor according to any one of claims 7-15 into an immune effector cell;

optionally, the immune effector cell is a T lymphocyte; further optionally, the source of the T lymphocyte is an autologous T lymphocyte or an allogeneic T lymphocyte; even further optionally, the allogeneic T lymphocyte comprises gene-edited *CD7/TRAC* double-negative cell;

most optionally, the T lymphocyte is an αβT lymphocyte or a γδT lymphocyte; or

optionally, *Trac* gene and *CD7* gene of T cell are gene-edited with gene editing tool to obtain *CD7/TRAC* double-negative cell; optionally, the gene editing tool is selected

from CRISPR/Cas system; further optionally, the CRISPR/Cas system comprises Cas9 protein and sgRNA; or

even further optionally, the sgRNA of the CRISPR/Cas system targeting *CD7* gene is shown in SEQ ID NO: 33; and/or, the chRDNA of the CRISPR/Cas system targeting *Trac* gene is shown in SEQ ID NO: 34.

20. Use of the humanized antibody or antigen-binding fragment thereof according to any one of claims 1-3, the isolated nucleic acid molecule according to claim 4, the cell according to claim 5, the chimeric antigen receptor according to any one of claims 7-15, the isolated nucleic acid molecule according to claim 16, or the engineered immune effector cell according to claim 17 in the preparation of a medicament, wherein the medicament is used for treating diseases or conditions related to the expression of CD7;

optionally, the diseases or conditions related to the expression of CD7 is a $CD7^+$ hematological tumor; further optionally, the $CD7^+$ hematological tumor is selected from one or more of $CD7^+$ T acute lymphoblastic leukemia, $CD7^+$ T-cell lymphoma, $CD7^+$ acute myelocytic leukemia;

even further optionally, the $CD7^+$ T acute lymphoblastic leukemia comprises $CD7^+$ early T cell precursor acute lymphoblastic leukemia and other T acute lymphoblastic leukemia; and/or wherein the $CD7^+$ T-cell lymphoma is selected from one or more of $CD7^+$ T-lymphoblastic lymphoma, $CD7^+$ extranodal NK/T-cell lymphoma, $CD7^+$ enteropathy-associated T-cell lymphoma, $CD7^+$ primary cutaneous T-cell lymphoma and $CD7^+$ peripheral T-cell lymphoma.