A Comparative Study of CRISPR-Cas9 Treatment and Conventional Diabetes Treatment

Ara Akinsanmi

Grade 8
Renert School

Table of contents

01

Introduction

Overview of diabetes and why it matters

02

Current Diabetes Treatments

How diabetes is managed today

03

Gene Editing Technologies

CRISPR, TALENs, and ZFN overview

04

Data Comparison

Table comparing treatments and gene editing

05

Conclusion

Future potential of CRISPR for diabetes + citations

06

Citations

All the sources used.

01

Introduction

Overview of diabetes and why it matters

Purpose statement

What is Diabetes?

- Chronic disease affecting blood sugar regulation
- Caused by lack of insulin or insulin resistance
- Leads to long-term health complications

Type 1 diabetes

- Autoimmune destruction of pancreatic beta cells
- Body stops producing insulin
- Requires lifelong insulin therapy

Why it matters.

- 537 million adults worldwide have diabetes
- Type 1 diabetes increasing 3–5% per year
- Over 1 million children and teens affected

3.9 million (9.7%)

Of people aged 1 year and older live with diagnosed diabetes (Canada, 2023–2024)

https://health-infobase.canada.ca/diabetes/

02

Current Diabetes Treatments

How diabetes is managed today

Insulin Replacement Therapy (Basal-Bolus)

- **Overview:**
  - Multiple daily injections or insulin pump
  - Basal insulin: long/intermediate-acting
  - Bolus insulin: rapid/short-acting, taken before meals
- **Safety:**
  - Hypoglycemia risk
  - Possible weight gain
  - Does not cure diabetes
- **Cost & Inconveniences:**
  - Moderate–high cost
  - Daily injections, frequent monitoring
  - Lifelong dependency
- **Future Potential:**
  - Could restore natural insulin production
  - May reduce or eliminate injections

Artificial Pancreas Systems

- **Overview:**
    - Continuous glucose monitoring (CGM) + insulin pump
    - Automated insulin delivery based on glucose readings
    - Mimics pancreatic feedback
- **Safety:**
    - Reduces hypoglycemia compared to manual injections
    - Possible device malfunctions
    - Skin irritation possible
- **Cost & Inconveniences:**
    - High upfront cost + ongoing supplies
    - Must wear device constantly
    - Device alarms, calibration, and technical learning curve
- **Future Potential:**
    - Gene-edited β-cells could replace devices
    - Reduces dependency on technology

Xenotransplantation

- **Overview:**
  - Transplant insulin-producing pig islet cells
  - Requires immune-suppressing drugs
- **Safety:**
  - High risk of immune rejection and infection
  - Ethical concerns about animal-to-human transplants
- **Cost & Inconveniences:**
  - Very high: surgery + lifelong immune-suppressing drugs
  - Major surgery with recovery risk
  - Ongoing monitoring to prevent rejection
- **Future Potential:**
  - Could make donor cells safer and more human-compatible
  - Still experimental, mostly preclinical research

These treatments manage diabetes but don’t cure it and require ongoing care.

03

Gene Editing Technologies

CRISPR, TALENs, and ZFN overview

CRISPR Cas9

- **How it works:** RNA-guided enzyme edits DNA at specific sites; can be done in stem cells (ex vivo) or directly in the body (in vivo)
- **Safety:** Temporary off-target effects possible; newer versions designed to be safer
- **Cost:** Medium–high; may reduce long-term costs if curative
- **Patient Impact:** Experimental; requires specialized centers; careful monitoring; ethical concerns for inheritable changes
- **Benefits:** Fixes disease at the genetic level; may restore natural insulin; targets root cause
- **Applications:** Used in rare genetic disorders (e.g., CPS1 deficiency); disease modeling

Transcription Activator-Like Effector Nucleases (TALENS)

- **How it works:** Protein-based system cuts specific DNA sequences; each protein recognizes one DNA base; done in stem cells.
- **Safety:** More precise than ZFNs, fewer off-target effects; can still incorrectly bind DNA; delivery into human cells challenging.
- **Cost:** High; custom protein design is time-consuming.
- **Patient Impact:** Experimental; complex lab work; not widely available clinically.
- **Benefits:** Can correct genetic mutations in stem cells; preclinical research shows potential.
- **Applications:** Research on genetic disorders; disease modeling in labs.

Zinc-Finger Nucleases (ZFN)

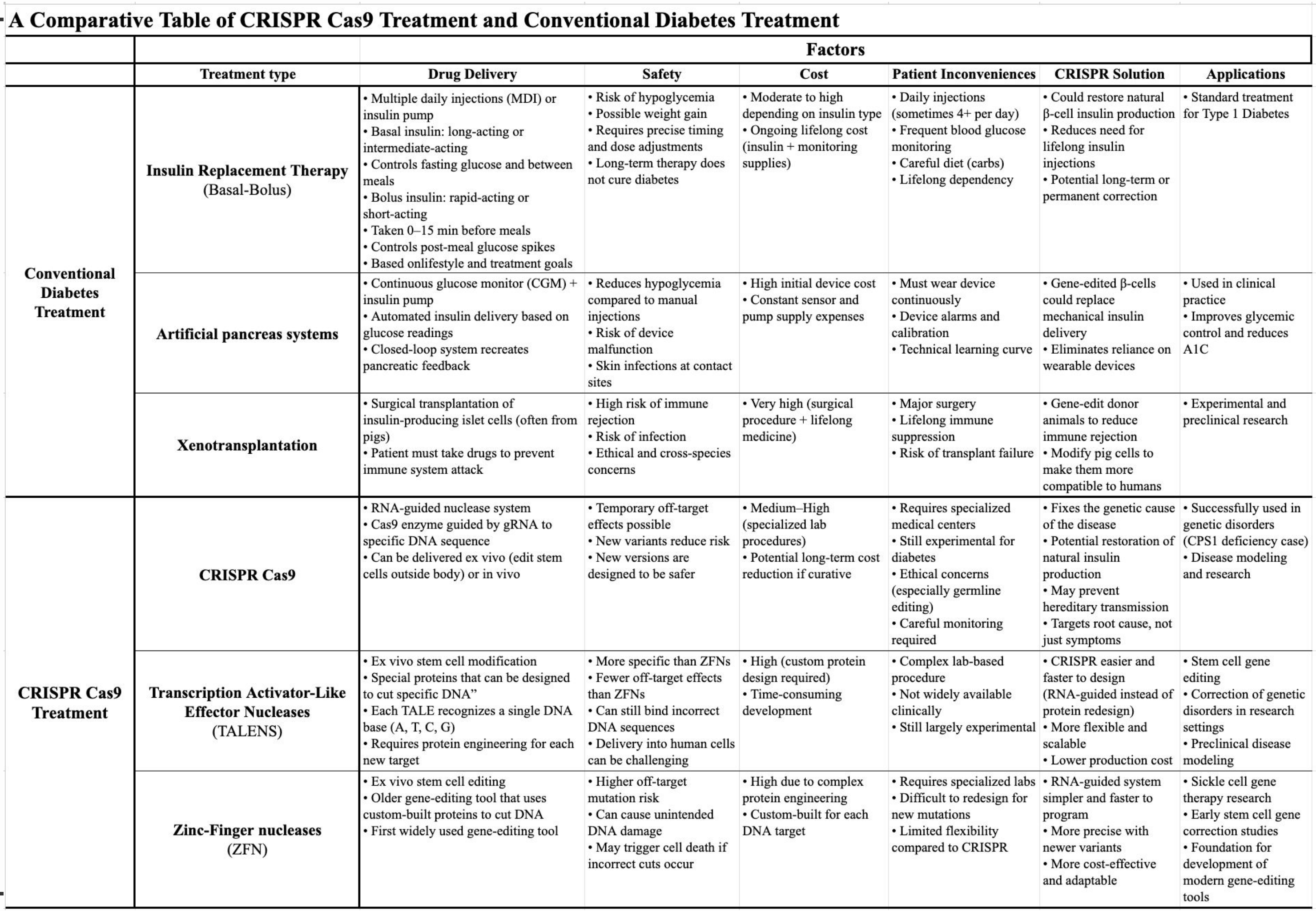
- **How it works:** Protein-based system edits DNA using engineered zinc finger domains; first widely used tool
- **Safety:** Higher off-target risk; can damage DNA; may trigger cell death
- **Cost:** High; complex protein engineering needed for each target
- **Patient Impact:** Experimental; difficult to redesign; limited flexibility
- **Benefits:** Foundation for modern gene-editing tools; early stem cell gene correction
- **Applications:** Sickle cell therapy research; early gene therapy studies.

These gene-editing tools are powerful but mostly still experimental.

04

Data Comparison

Table comparing treatments and gene editing



A Comparative Table of CRISPR Cas9 Treatment and Conventional Diabetes Treatment

		Factors					
	Treatment type	**Drug Delivery**	**Safety**	**Cost**	**Patient Inconveniences**	**CRISPR Solution**	**Applications**
Conventional Diabetes Treatment	**Insulin Replacement Therapy** (Basal-Bolus)	• Multiple daily injections (MDI) or insulin pump • Basal insulin: long-acting or intermediate-acting • Controls fasting glucose and between meals • Bolus insulin: rapid-acting or short-acting • Taken 0–15 min before meals • Controls post-meal glucose spikes • Based onlifestyle and treatment goals	• Risk of hypoglycemia • Possible weight gain • Requires precise timing and dose adjustments • Long-term therapy does not cure diabetes	• Moderate to high depending on insulin type • Ongoing lifelong cost (insulin + monitoring supplies)	• Daily injections (sometimes 4+ per day) • Frequent blood glucose monitoring • Careful diet (carbs) • Lifelong dependency	• Could restore natural β-cell insulin production • Reduces need for lifelong insulin injections • Potential long-term or permanent correction	• Standard treatment for Type 1 Diabetes
	Artificial pancreas systems	• Continuous glucose monitor (CGM) + insulin pump • Automated insulin delivery based on glucose readings • Closed-loop system recreates pancreatic feedback	• Reduces hypoglycemia compared to manual injections • Risk of device malfunction • Skin infections at contact sites	• High initial device cost • Constant sensor and pump supply expenses	• Must wear device continuously • Device alarms and calibration • Technical learning curve	• Gene-edited β-cells could replace mechanical insulin delivery • Eliminates reliance on wearable devices	• Used in clinical practice • Improves glycemic control and reduces A1C
	Xenotransplantation	• Surgical transplantation of insulin-producing islet cells (often from pigs) • Patient must take drugs to prevent immune system attack	• High risk of immune rejection • Risk of infection • Ethical and cross-species concerns	• Very high (surgical procedure + lifelong medicine)	• Major surgery • Lifelong immune suppression • Risk of transplant failure	• Gene-edit donor animals to reduce immune rejection • Modify pig cells to make them more compatible to humans	• Experimental and preclinical research
CRISPR Cas9 Treatment	**CRISPR Cas9**	• RNA-guided nuclease system • Cas9 enzyme guided by gRNA to specific DNA sequence • Can be delivered ex vivo (edit stem cells outside body) or in vivo	• Temporary off-target effects possible • New variants reduce risk • New versions are designed to be safer	• Medium–High (specialized lab procedures) • Potential long-term cost reduction if curative	• Requires specialized medical centers • Still experimental for diabetes • Ethical concerns (especially germline editing) • Careful monitoring required	• Fixes the genetic cause of the disease • Potential restoration of natural insulin production • May prevent hereditary transmission • Targets root cause, not just symptoms	• Successfully used in genetic disorders (CPS1 deficiency case) • Disease modeling and research
	Transcription Activator-Like Effector Nucleases (TALENS)	• Ex vivo stem cell modification • Special proteins that can be designed to cut specific DNA” • Each TALE recognizes a single DNA base (A, T, C, G) • Requires protein engineering for each new target	• More specific than ZFNs • Fewer off-target effects than ZFNs • Can still bind incorrect DNA sequences • Delivery into human cells can be challenging	• High (custom protein design required) • Time-consuming development	• Complex lab-based procedure • Not widely available clinically • Still largely experimental	• CRISPR easier and faster to design (RNA-guided instead of protein redesign) • More flexible and scalable • Lower production cost	• Stem cell gene editing • Correction of genetic disorders in research settings • Preclinical disease modeling
	Zinc-Finger nucleases (ZFN)	• Ex vivo stem cell editing • Older gene-editing tool that uses custom-built proteins to cut DNA • First widely used gene-editing tool	• Higher off-target mutation risk • Can cause unintended DNA damage • May trigger cell death if incorrect cuts occur	• High due to complex protein engineering • Custom-built for each DNA target	• Requires specialized labs • Difficult to redesign for new mutations • Limited flexibility compared to CRISPR	• RNA-guided system simpler and faster to program • More precise with newer variants • More cost-effective and adaptable	• Sickle cell gene therapy research • Early stem cell gene correction studies • Foundation for development of modern gene-editing tools

Data

Compares conventional vs. CRISPR-based diabetes treatments

Conventional: manage blood sugar, daily routines, risks, high cost

CRISPR/TALENs/ZFNs: edit genes to fix root cause, make more convenient potential long-term cure

Mostly experimental, expensive now

Could transform future diabetes care

Promising for hereditary and Type 1 diabetes

05

Conclusion

Future potential of CRISPR for diabetes + citations

CRISPR Cas9 Impact

- Targets the root cause of Type 1 diabetes, no symptoms.
- Potential to permanently restore insulin production by fixing faulty genes.
- Example: CPS1 deficiency treatment in a 7-month-old infant.
  - Base editing changes one DNA letter wit cutting both strands → safer.
  - Delivered via lipid nanoparticles with custom gRNA and mRNA.
  - Result: lower ammonia, better protein tolerance, reduced medication, improved growth

Key Takeaway:

Personalized CRISPR therapies can be safe and effective

Future Diabetes Treatments

Goal:

Restore insulin production and regulation, aiming for long-term insulin independence.

- Type 1 diabetes cases are rising worldwide; insulin therapy manages but does not cure.
- Promising strategies for the future:
    - Artificial pancreas systems
    - Stem cell-derived beta cells
    - Xenotransplantation
    - Combination therapies

Why Research CRISPR?

- CRISPR Cas9 is still experimental but shows strong potential.
- Could revolutionize diabetes care by addressing the root genetic causes.
- Benefits:
    - Fewer lifelong injections
    - Reduced patient burden
    - Potential permanent treatment instead of symptom management

Conclusion:

Continued research is crucial for safer, more effective gene-editing therapies.

While insulin therapy remains a temporary treatment, the emerging field of gene editing, specifically with the CRISPR Cas9 should continue to be researched and studied, because of the strong success rate of it, and potential that would permanently change the healthcare system.

06

Citations

All the sources used

(n.d.). https://pmc.ncbi.nlm.nih.gov/articles/PMC12033450/#sec2-14791641251334726

(n.d.). https://pmc.ncbi.nlm.nih.gov/articles/PMC5815912/

(n.d.). https://pmc.ncbi.nlm.nih.gov/articles/PMC6058482/

The art of vector engineering: towards the construction of next-generation genetic tools. (n.d.). PMC. Retrieved March 2, 2026, from https://pmc.ncbi.nlm.nih.gov/articles/PMC6302727/

Cas9 protein delivery non-integrating lentiviral vectors for gene correction in sickle cell disease. (2021). Retrieved February, 2026, from https://www.cell.com/molecular-therapy-family/advances/fulltext/S2329-0501%2821%2900037-1

Challenges in delivery systems for CRISPR-based genome editing and opportunities of nanomedicine. (n.d.). PMC. Retrieved March 2, 2026, from https://pmc.ncbi.nlm.nih.gov/articles/PMC8316527/

Diabetes Prevention | ADA. (n.d.). Diabetes.org. Retrieved March 2, 2026, from https://diabetes.org/about-diabetes/diabetes-prevention

Genetics of Diabetes. (n.d.). American Diabetes Association. Retrieved March 2, 2026, from https://diabetes.org/about-diabetes/genetics-diabetes

Genome engineering and disease modeling via programmable nucleases for insulin gene therapy: Promises of CRISPR/Cas9 technology Eksi YE, Sanlioglu AD, Akkaya B, Ozturk BE, Sanlioglu S. Genome engineering and disease modeling via programmable nucleases for . (2021). Wignet. Retrieved February, 2025, from https://www.wjgnet.com/1948-0210/full/v13/i6/485.htm?appgw_azwaf_jsc=XU8ijqJujiB-gQuktGm7goqyBiz5k8CifpHmTOl6eCLiseAhlux08UV3V6zX-SStleeZzK8dwjNAKOx2BbQJwapX96t2B7RDukph5K1PMpmi4SoBC5hHsbzwlIq8_e35BkI9ocfyHe6JbIBWQQ_OKUz6CiBu8CeCP52kB3suqBzkDODQm7F9LmqTyol

Glycemic Management in Adults With Type 1 Diabetes. (2018). Retrieved March 2, 2025, from https://guidelines.diabetes.ca/cpg/chapter12#bib0010

https://pmc.ncbi.nlm.nih.gov/articles/PMC6501476/. (2019, May 3). PubMedCentral. Retrieved March 2, 2026, from https://pmc.ncbi.nlm.nih.gov/articles/PMC6501476/

Non Viral Vectors in Gene Therapy- An Overview. (2015, January 1). PMC. Retrieved March 2, 2026, from https://pmc.ncbi.nlm.nih.gov/articles/PMC4347098/

Off-target effects in CRISPR/Cas9 gene editing. (n.d.). PMC. Retrieved March 2, 2026, from https://pmc.ncbi.nlm.nih.gov/articles/PMC10034092/

Patient-Specific In Vivo Gene Editing to Treat a Rare Genetic Disease. (2025). Retrieved 2026, from https://pmc.ncbi.nlm.nih.gov/articles/PMC12713542/

Srinivasan, M. (2021, December 19). *Gene Therapy - Can it Cure Type 1 Diabetes?* PMC. Retrieved March 2, 2026, from https://pmc.ncbi.nlm.nih.gov/articles/PMC8723777/

Type 1 diabetes - Diagnosis and treatment. (2024, March 27). Mayo Clinic. Retrieved March 2, 2026, from https://www.mayoclinic.org/diseases-conditions/type-1-diabetes/diagnosis-treatment/drc-20353017

What is Gene Therapy? (2025, February 14). YouTube. Retrieved March 2, 2026, from https://youtu.be/WmJAyyUqaZU

Thank you for your time.