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Advanced Treatment of Type 1 Diabetes with Teplizumab: Mechanism and Clinical Efficacy

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Teplizumab, a humanized anti-CD3 monoclonal antibody, has emerged as a significant advancement in the treatment of type 1 diabetes (T1D), an autoimmune disease characterized by the destruction of insulin-producing pancreatic beta cells. As the first FDA-approved disease-modifying drug for T1D, teplizumab has demonstrated efficacy in delaying the onset of stage 3 T1D in adults and pediatric patients 8 years and older with stage 2 T1D. Clinical trials have shown that teplizumab can preserve beta cell function, reduce insulin requirements, and improve glycemic control in newly diagnosed T1D patients. The drug's mechanism of action involves modulating the immune response responsible for beta cell destruction by altering the function of T-lymphocytes, inducing regulatory T cells, and promoting the accumulation of exhausted-like CD8 T cells.

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Teplizumab's efficacy appears to be influenced by factors such as the microbiome and the induction of partially exhausted CD8 T cells, which exhibit reduced secretion of inflammatory cytokines. While teplizumab has shown promise in preserving beta cell function and delaying T1D onset, challenges remain in optimizing treatment protocols and addressing potential side effects, including lymphopenia and skin disorders. Future research directions include exploring combination therapies, identifying predictive biomarkers, and refining patient selection to maximize treatment outcomes. Teplizumab's success in T1D has implications for the broader field of immunotherapy in autoimmune diseases, demonstrating the potential of targeted immunomodulation in altering disease.

Keywords: Teplizumab; type 1 diabetes; autoimmune disease; beta cells; FDA-approved; disease-modifying drug; delayed onset; preserved beta cell function; modulating immune response; immunotherapy.

1. INTRODUCTION

1.1 Background on Type 1 Diabetes (T1D) and its Autoimmune Nature

Type 1 Diabetes (T1D) is a chronic autoimmune disease that is characterized by the specific destruction of the insulin-producing pancreatic beta cells, leading to severe insulin deficiency and hyperglycemia (Bastos et al., 2015; Assmann et al., 2015). The autoimmune process usually commences in genetically predisposed subjects mostly affected in childhood and adolescence (Bastos et al., 2015). The destruction of beta cells is progressive, and clinical manifestations typically set in once more than 80% of the cells are gone[2]. However, it is important to note that the autoimmune nature of T1D cannot be said to rest on any dysregulation of the immune system exclusively. Recent studies suggest that some apoptosis ensues as the beta cells engage in complex interactions with the immune system (Toren et al., 2021). This fundamentally challenges the view that T1D is merely an immune-mediated disease and places greater importance on understanding the vulnerability and heterogeneity of beta cells in disease progression. T1D pathogenesis arises from a complex interplay among the genetic factors, environmental triggers, and the resulting immune responses (D'Addio et al., 2024; Long & Buckner, 2022). Although genetic susceptibility majorly affects, with HLA-DQ being one risk factor, many of those diagnosed with T1D have no family history or high-risk HLA haplotypes (D'Addio et al., 2024). Such heterogeneity in disease onset and progression depicts the requirements For a better understanding of T1D pathogenesis that could lead to partly the concept of T1D endotypesand personalization of disease diagnosis and treatment (D'Addio et al., 2024; Dooley et al., 2016).

1.2 Overview of the Significance of Teplizumab Treatment

Eplizumab is a CD3-directed monoclonal antibody that is a significant milestone in type 1 diabetes (T1D) treatment. It was approved in November 2022 in the USA for delaying the onset of Stage 3 T1D among adult and pediatric patients aged 8 years and older who are suffering from Stage 2 T1D (Keam, 2023). First promising examples of retaining beta cell function and delaying the diagnosis of T1D in high-risk individuals have emerged (Sims et al., 2021).

Interestingly, the effect of teplizumab extends long ahead of the immediate treatment. Teplizumab treatment for a period of 14 days demonstrated extended effects characterized by delaying T1D diagnosis and retaining beta cell function in high-risk individuals (Sims et al., 2021). There are evidence that drug can induce specific and substantial changes in T cell function and reactivity, still after 3 months and as lasting as 18 months after drug treatment began (Budhavarapu et al., 2024). Teplizumab may induce long-lasting immune changes that contribute to its ameliorative effect. As a conclusion, teplizumab represents a huge breakthrough in T1D treatment, offering the first-ever therapy to modify a disease for individuals at risk of developing T1D. This could significantly improve the quality of life for patients by maintaining insulin production and delaying the onset of the disease. However, while it shows much promise, teplizumab is also associated with potential adverse effects with respect to the gastrointestinal, dermatological, and hematolo gical systems (Budhavarapu et al., 2024). Ongoing research builds this up further to enhance both its efficacy and safety profile (Ahmed et al., 2023).

2. THE IMMUNE SYSTEM IN T1D

2.1 Description of the Immune System's Role in T1D

Teplizumab is a humanized monoclonal antibody tethered to CD3 antigen and plays a critical role in modulation of immune response in type 1 diabetes (T1D). In T1D, destruction of insulin-producing β-cells begins with the activation of effector T-lymphocytes that are cytotoxic (Pillemer, 2008). Teplizumab does induce regulatory T-cells (Tregs) responses and inhibits inflammatory and destructive processes taking place in target tissues[11,12]. Interestingly, teplizumab's mode of action is one that complexes immunological arrayed changes. PD-1+ Foxp3+ Treg cell numbers were observed to rise in the ones off anti-drug antibodies in their first course of therapy (Long et al., 2017). Additionally, teplizumab was found to enhance the population of CD8 T-cells resembling exhausted T-cells characterized by high expression of EOMES transcription factors, effector molecules, and multiple inhibitory receptors (Long et al., 2016). In conclusion, teplizumab complexes multiple mechanisms in the immune system of T1D, including induction of Tregs, modulation of CD4 and CD8 populations, and promotion of T-cell exhaustion. These synergized immunomechanisms underlie the ability of the drug in preserving β-cell function and delaying the onset of T1D in high-risk individuals (Fanaropoulou et al., 2024; Herold et al., 2013; Seewoodhary & Silveira, 2023; Masharani & Becker, 2010).

2.2 Mechanisms of T-cell Involvement in β-cell Destruction

Phase III clinical trials which are underway for teplizumab have shown promise in delaying the onset of T1D (Masharani & Becker, 2010; Thakkar et al., 2023). Teplizumab works on multiple targets and inhibits the autoimmune destruction of insulin-producing β-cells mediated by effector T-lymphocytes (Pillemer, 2008). Mechanism-wise, teplizumab has demonstrated increased Treg activity and promotes immune tolerance (Thakkar et al., 2023). The use of teplizumab has led to the transient increasing of PD-1+Foxp3+ Tregs and perhaps a CD4 T cell that was not capable of functioning any longer, as well as a profound tally of exhausted CD8 T cells (Long et al., 2017). The phenotypic changes across T cells were correlated with great treatment responses in the nonresponders to therapies, who otherwise developed anti-drug antibodies (Long et al., 2017). To sum up, teplizumab protects β-cell function by modulating multiple T-cell subtypes that include enhancing Treg function while inhibiting the activation of effector CD4 and CD8 T cells (Long et al., 2017). This coordinated immune modulation may contribute to halting the autoimmune destruction of β-cells in T1D. The underlying mechanisms remain ambiguous, however, and additional work will be needed before the intricate immunological effects of teplizumab in T1D might be known (Long et al., 2017; Vudattu & Herold, 2014).

3. OVERVIEW OF TEPLIZUMAB

3.1 Overview of Teplizumab

Humanized anti-CD3 monoclonal antibody that acts to prevent and treat type 1 diabetes (T1D) (Keam, 2023; Ahmed et al., 2023). This includes the first from the FDA to have its use in delaying the onset of stage 3 T1D in patients aged 8 years or older with stage 2 T1D. Teplizumab alters the function of T-lymphocytes that mediate the destruction of insulin-producing β-cells in the pancreas (Skelley et al., 2012). Clinical trials have demonstrated teplizumab's efficacy in preserving C-peptide response, reducing exogenous insulin use, and improving glycemic control in newly diagnosed T1D patients (Ma et al., 2024; Kamrul-Hasan et al., 2024; Nourelden et al., 2021). Not all patients respond similarly to the drug and the duration of response for some can be up to 7 to 10 months (Herold et al., 2013). Interestingly, metabolic and immunologic features at baseline may help identify subgroups with robust responses to teplizumab (Herold et al., 2013). However, teplizumab not only had great promise in T1D management is also associated with a few adverse effects. These side effects can include skin rashes, upper respiratory infections, headaches and nausea (Herold et al., 2013). Likewise, when prescribed teplizumab, patients carry a greater risk of experiencing gastrointestinal, dermatological, and hematological side effects from treatment, with already the potential risk for serious side effects and/or even active Epstein-Barr Virus infection (Budhavarapu et al., 2024). Though many such side effects may seem serious, teplizumab is seen as a major advancement in T1D therapy with a new way to slow down disease progression in T1D patients and perhaps improve their long-term health outcomes.

3.2 Pharmacological Profile and Classification of Monoclonal Antibodies

Teplizumab is humanized anti-CD3 monoclonal antibody that modifies the function of T-lymphocytes in the destruction of insulin-producing β-cells in type 1 diabetes (T1D) (Skelley et al., 2012). It is an immunomodulatory agent that belongs to a class of CD3-directed monoclonal antibodies (Keam, 2023). Teplizumab works by targeting CD3-+ cells, which activate T-lymphocytes of both CD4-+ and CD8-+ types for the destruction of pancreatic beta-cells in T1D (Sharma et al., 2025). Fascinatingly, while teplizumab shows promise in delaying the onset of stage 3 T1D in high-risk individuals, its efficacy may vary depending on the timing of administration and dosage. A Phase 3 trial did not establish the benefit in T1D patients diagnosed with T1D within the past 12 weeks with the lower cumulative dose (Skelley et al., 2012). It stresses the need for determining the right dose and time to make monoclonal antibodies reach their therapeutic potential. In conclusion, teplizumab showcases the pharmacological complexity of monoclonal antibodies, highly selective, specific, and enduring in the body (Wang et al., 2008). Its approval has been a landmark achievement in the treatment of T1D (Keam, 2023; Sharma et al., 2025). Remarkably, like all monoclonal antibodies, teplizumab may face an uphill task in terms of bioavailability, absorption, and potential immune responses, and hence deserves meticulous investigation to display its application in clinical practices and further scrutiny.

4. MECHANISM OF ACTION

4.1 Detailed Explanation of Teplizumab's Interaction with the Immune System

Teplizumab is an Fc receptor non-binding anti-CD3 monoclonal antibody that acts through various mechanisms to modulate the immune system and control T1D progression. Teplizumab modulates T cell populations by decreasing circulation CD4+ effector memory T cells while increasing the CD8+ T cell population, specifically CD8+CM in clinical responders (Tooley et al., 2016). The expanded CD8+CM T cells show evidence of proliferation and also differentiation from non-CM T cells. These CD8CM T cells showed decreased expression of genes related to immune activation and increased expression of genes related to T cell differentiation and regulation (Tooley et al., 2016). Furthermore, it has been shown to induce regulatory CD8+ T cells (CD8+ Treg) capable of inhibiting CD4+ T cell proliferation-somehow in reliance on TNF and CCL4 (Ablamunits et al., 2010). They express markers of CD25, CTLA-4, Foxp3, and TNFR2 with the subpopulation capable of co-expressing TNFR2 and CD25 classifiable as a very potent one (Ablamunits et al., 2010). Interestingly, teplizumab causes gut-tropic CCR6+ T cells to migrate to the small intestine, where they produce the regulatory cytokine IL-10 (Waldron-Lynch et al., 2012). This effect becomes a key element in the efficacy of the drug since blocking the milieu will render treatment through teplizumab futile (Waldron-Lynch et al., 2012). The long-term effects include induction of the partially exhausted profile in CD8+ T cells expressing EOMES and the effector molecules along with a wide range of inhibitory receptors like TIGIT and KLRG1 (Long et al., 2016). These cells recognize a broad spectrum of environmental and auto-antigens but are hypo-proliferative in response to stimulation-polyclonal. In summary, teplizumab interacts with the immune system by modulating T cell numbers, inducing regulatory T cells, changing T cell migration patterns, and rendering T cells: still preferring a state of-exhausted state among CD8+ T cells. All of these mechanisms contribute to the drug's ability to delay T1D progression in at-risk patients and preserve β-cell function in patients with early-onset T1D.

4.2 Effects on CD3 Signaling and T Cell Modulation

Teplizumab, being an anti-CD3 monoclonal antibody, has some significant effects on CD3 signaling and T cell modulation in type 1 diabetes (T1D). The molecule acts on CD3 critical for T cell activation and signaling (Ceuppens et al., 1986). Teplizumab operates through modulation of CD3 on T cells resulting in altered T cell function and phenotype. Studies have shown that teplizumab treatment decreases circulating CD4+ effector memory T cells but does increase CD8+ central memory T cells in clinical responders (Tooley et al., 2016). These CD8CM T cells show lowered expression of activation genes and increased expression of genes related to T cell differentiation and regulation. Furthermore, teplizumab expands the KLRG1+TIGIT+CD8+ T cell subpopulation with partial exhaustion, as evidenced by diminished secretion of the pro-inflammatory cytokines IFNγ and TNFα (Sims et al., 2021; Long et al., 2016).

Notably, T cells experience a biphasic response after teplizumab treatment: any initial transcriptional signature of cellular activation-a phenomenon expressed in both CD4+ and CD8+ T cells-will revert to lower levels of expression of genes involved in T cell receptor and activation signaling pathways in clinical responders over time (Lledó-Delgado et al., 2024). This ultimately will promote operational tolerance in T1D in a manner where T cells activate, successively show exhaustion and regulation. Besides, teplizumab treatment wards off autoreactive CD8+ T cells from profusing in groups at the control[33]. Therefore, the actions of teplizumab on CD3 signaling and T cell modulation are complex and multilayered. The drug modifies the composition of T cell subsets, alters the expression profiles of genes and induces a state of partial exhaustion and regulation in CD8+ T cells. These immunomodulated effects contribute to the delay in T1D progression and better beta cell function that have been observed in clinical trials (Keam, 2023; Sims et al., 2021). The ability of teplizumab to induce these changes in T cell function and phenotype highlights its potential as a promising therapeutic approach for T1D management.

4.3 Consequences for Beta Cell Preservation and Insulin Production

The new research has used teplizumab for considerable beta cell function preservation and to delay the onset of type 1 diabetes (T1D). Clinical trials have established that teplizumab can stabilize C-peptide, ano that must be preserved to assess the function of beta cells, and the use of exogenous insulin diminished, particularly for patients who had an onset of T1D (Kokori et al., 2024). In high-risk subjects, teplizumab would delay the median time to market diagnosis by about 24 months compared to placebo (48.4 vs 24.4 months) (Herold et al., 2019). Interestingly, the effects of teplizumab seemed to persist even beyond the treatment period. Some subjects have shown long-lasting positive results, with teplizumab halting the severe decline of beta cells and perhaps even contributing to their recovery after treatment among high-risk populations (Białek et al., 2023; Wagner & Bleich, 2023). Nevertheless, it has to be borne in mind that, notwithstanding the promise of teplizumab in trial patients, long-term blood glucose modulation and insulin requirement has not yet been established in everyone (Wagner & Bleich, 2023). In conclusion, teplizumab represents a significant development in the management of T1D, with the promise of delaying disease onset and preserving beta cell function. Its immune-modulating capacity and potential to enhance beta cell function give teplizumab the prospect of a disease-modifying treatment for T1D (LeFevre et al., 2022). However, more work is needed towards optimizing treatment regimens, identifying ideal patient populations, and exploring combination therapies to maximize benefits in insulin production and beta cell function preservation (Fanaropoulou et al., 2024).

5. CLINICAL EVIDENCE

5.1 Summary of Major Clinical Trials and Studies

Teplizumab, an FcR nonbinding anti-CD3 monoclonal antibody, has been shown to have therapeutic effects in several randomized clinical trials on type 1 diabetes (T1D) (Tooley et al., 2016). Multiple trials have demonstrated its efficacy in preserving β-cell function and decreasing insulin dependence in T1D patients. A systematic review and meta-analysis of 8 RCTs found that teplizumab was effective in substantially reducing the need for insulin and improving C-peptide levels, implying an intrinsic generation of the insulin. No significant alteration of HbA1c levels was noted (Heidari et al., 2024). Another meta-analysis of 8 RCTs with 1908 T1D patients showed findings consistent with the previous analysis; decreased insulin consumption, enhanced C-peptide responses and significant changes in HbA1c with reported minimum side effects (Ma et al., 2024). Quite interestingly however, other studies reported conflicting results. The phase 3 study of 516 patients showed no significant difference between teplizumab and placebo arms with respect to the primary outcome endpoint, defined as the percentage of patients with insulin use of less than 0.5 U/kg each day and HbA1c less than 6.5% at 1 year. Only 5% of teplizumab patients were free from insulin therapy at 1 year versus none in the placebo group (Sherry et al., 2011). Thus, while the majority of studies support teplizumab in the preservation of β-cell function and decreased insulin dependence in T1D patients, there are trials that have also suggested conflicting results. Safety profiles appear well established, given that rashes represented the most frequent adverse event (Sherry et al., 2011). Opening further lines of research will be required to mandate an appropriate dose

regimen together with the patient population that will optimally benefit from tepluzimab treatment.

5.2 Efficacy outcomes Regarding Beta Cell Function and Long-term Diabetes Management

Teplizumab therapy indeed shows optimistic efficacy results, particularly towards pancreatic beta cell function and its long-term management for the case of type 1 diabetes (T1D). Studies have demonstrated that a single 14-day course of teplizumab treatment could delay T1D diagnosis significantly while improving beta cell function in high-risk individuals. In a randomized controlled trial with extended follow-up, median time to diagnosis was 59.6 months in teplizumab-treated individuals, compared to 27.1 months in placebo-treated individuals (Sims et al., 2021). Notably, 50% of those treated with teplizumab remained diabetes-free, in contrast to 22% of placebo participants. Treatment with teplizumab also improved beta cell function, as shown by greater average C-peptide area under the curve (1.94 vs. 1.72 pmol/ml; P = 0.006) (Sims et al., 2021). Interestingly, the efficacy of teplizumab seems to be correlated with some changes in T cell subsets. C-peptide levels improved with the rise of partially exhausted memory KLRG1+TIGIT+CD8+ T cells, which were shown to produce lower levels of inflammatory cytokines lFNγ and TNFα. It indicates that teplizumab may act directly upon the immune response, thereby allowing the preservation of beta cell function. To conclude, teplizumab therapy is promising for delaying T1D onset, preserving beta cell function, and facilitating long-term management of diabetes. The ongoing positive result of a single course of treatment on both clinical outcomes and immunological parameters gives it renewed promise as a novel therapeutic approach in T1D. Further research is still required to develop better treatment protocols and to assess long-term safety and efficacy outcomes in larger patient populations (Kokori et al., 2024; Salama et al., 2024).

5.3 Comparative Analysis with Other Treatments

Teplizumab is a CD3-directed monoclonal antibody that shows preliminary promise for treatment and prevention of type 1 diabetes (T1D). Several studies have shown its effect in the preservation of β-cell function and in decreasing the insulin requirement in T1D (Kamrul-Hasan et al., 2024; Heidari et al., 2024 Ma et al., 2024). When compared to placebo, teplizumab demonstrated consistently greater outcomes in maintaining C-peptide levels, a marker of endogenous insulin production. Meta-analyses demonstrated that C-peptide levels were significantly elevated in teplizumab-treated groups compared to control groups at various time points up to 24 months after treatment (Kamrul-Hasan et al., 2024; Heidari et al., 2024). Furthermore, teplizumab treatment was correlated with decreased use of exogenous insulin with comparable glycemic control (Herold et al., 2013; Kamrul-Hasan et al., 2024). Interestingly, while teplizumab has demonstrated apparent benefits in preserving β-cell function and decreasing insulin dependence, whether this affects long-term glycemic control, as measured by HbA1c levels, remains undetermined. Some studies describe significant changes in HbA1c levels (Ma et al., 2024), but others have found no significant differences among teplizumab and placebo groups (Heidari et al., 2024). Such differences underscore the need for further studies elucidating teplizumab long-term glycemic effects. In summary, teplizumab adds to the latest advances in T1D treatment, which offer a disease-modifying approach that goes beyond traditional insulin therapy. Its ability to postpone the onset of stage 3 T1D in high-risk individuals and preserve β-cell function in patients newly diagnosed with the disease positions it as a promising therapeutic opportunity. However, inherent variability in response to treatment and the need for repeated dosing indicates that further research is needed to develop better treatment protocols for the identification of the most suitable recipient population for this therapy.

6. CHALLENGES AND SAFETY CONSIDERATIONS

6.1 Overview of Potential Side Effects and Risks

This includes teplizumab, a monoclonal antibody targeted against CD3 that was approved for delaying the onset of Stage 3 T1D among patients at risk. These results are promising despite the potential tradeoffs. Various adverse effects have been reported with teplizumab treatment (Keam, 2023). Patients receiving teplizumab had a greater risk of developing gastrointestinal, dermatological, and hematological side effects than the placebo.

Specifically, this included a considerable increase in the odds of nausea, rash, and lymphopenia (Budhavarapu et al., 2024; Kamrul-Hasan et al., 2024). Moreover, teplizumab-treated patients had a higher risk of active Epstein-Barr virus infection (Budhavarapu et al., 2024). Notably, while individual adverse effects were enriched for teplizumab, no individual study reported significantly elevated total adverse effects from teplizumab relative to placebo (Kamrul-Hasan et al., 2024). Studies provide contradictory evidence as to whether teplizumab is correlated with higher-grade adverse events and discontinuation events. Overall, teplizumab shows promise in delaying T1D progression but exhibits multiple side effects, the main ones affecting the gastrointestinal, dermatological, and hematological systems. Teplizumab's safety profile requires monitoring, given that this drug is newly introduced and hardly has any long-term data available to predict the safety and consequential benefit of teplizumab treatment. However, post-marketing surveillance and more research is needed to address safety, tolerability, and efficacy-related issues with teplizumab treatment (Budhavarapu et al., 2024; (Budhavarapu et al., 2024).

6.2 Consideration of Patient Eligibility and Monitoring Protocols

Teplizumab, a CD3-directed monoclonal antibody, has shown promise in delaying the onset of stage 3 type 1 diabetes (T1D) in high-risk individuals. Patient eligibility for teplizumab treatment typically includes adults and children aged 8 years and older with stage 2 T1D (Keam, 2023; Garg et al., 2023). The drug is administered parenterally over a 14-day course (Heidari et al., 2024; Herold et al., 2023), with some studies evaluating the effects of one or two courses. Monitoring protocols for teplizumab treatment involve assessing several key parameters. C-peptide levels are consistently used as a primary outcome measure, indicating endogenous insulin production. Insulin use and HbA1c levels are also monitored to evaluate the drug's efficacy in maintaining glycemic control (Heidari et al., 2024; Nourelden et al., 2021). Additionally, safety monitoring is crucial, with common adverse events including lymphopenia, rash, and headache, which generally resolve without intervention (Herold et al., 2023). Interestingly, a study found that parents with prior experience of diabetic ketoacidosis (DKA) showed a higher inclination to consent to teplizumab treatment for their at-risk children (Bombaci et al., 2024). This highlights the importance of educating patients and caregivers about the potential benefits and risks of teplizumab. Long-term monitoring of T cell phenotypes and gene expression patterns may also be valuable, as persistent EOMES expression was identified as a predictor for the time to clinical T1D diagnosis (Lledó Delgado et al., 2024).

7. FUTURE PERSPECTIVES

7.1 Emerging Research Directions and Potential for Combination Therapies

Whereas teplizumab, a humanized anti-CD3 monoclonal antibody, has become an ideal candidate disease-modifying therapy for T1D, it has shown efficacy in delaying T1D onset in at-risk individuals and preserving insulin production in newly diagnosed patients (Salama et al., 2024; Hirsch, 2023). Clinical trials have demonstrated such teplizumab treatment to slow the decline of C-peptide production, improve glycemic control, and decrease exogenous insulin requirement for up to two years post-treatment (Kamrul-Hasan et al., 2024; Herold et al., 2023). Interestingly, research has identified subgroups of responders with unique metabolic and immunological attributes, to the effect that future applications may focus on personalized treatment approaches (Herold et al., 2023; Fanaropoulou et al., 2024). This finding opens a new area of investigation for the identification of predictive biomarkers that could point to the patients most likely to benefit from teplizumab therapy. In one regard, teplizumab shows promise as a monotherapy, but with an increase in various combination therapies to enhance its efficacy to address the multifaceted nature of T1D pathogenesis. Future research directions for teplizumab, optimizing treatment regimens, long-term efficacy and safety, and exploring for potential synergies with other emerging therapies such as mesenchymal stem cells, gene therapy (Salama et al., 2024), and islet transplantation. In addition, studies are needed to evaluate the cost and effectiveness of teplizumab treatment, address challenges of treatment accessibility, and explore for its possible applications in other autoimmune diseases (Fanaropoulou et al., 2024). As T1D therapy keeps on evolving, teplizumab remains a great milestone, with research around it ongoing to optimize its therapeutic potential and improve patient outcomes.

7.2 Teplizumab's Role in the Broader Context of Immunotherapy for autoimmune Diseases

Teplizumab is an anti-CD3 monoclonal antibody that could make a significant advance in immunotherapy for autoimmune diseases, especially Type 1 Diabetes (T1D). It shows some promise in delaying T1D onset in individuals at a higher risk of developing this disease and/or slowing disease progression in newly diagnosed with stem cell support and targeted immunotherapy using monoclonal antibodies such as rituximab have found their way in Multiple Sclerosis, systemic sclerosis, and Rheumatoid arthritis (Cohen & Nagler, 2004). This suggests that essential principles will underline teplizumab effectiveness in broader contexts into autoimmune disease management.

8. CONCLUSION

The success of teplizumab in T1D treatment reflects the potential of targeted immunotherapy in dealing with autoimmune diseases. Its ability to delay the onset of disease and slow its progression demonstrates a paradigm shift in the management of T1D (Novograd & Frishman, 2024). As research progresses, the role of teplizumab may expand, and applications akin to it for other autoimmune conditions could develop, revolutionizing their treatment strategies.

patients (Thakkar et al., 2023; Fanaropoulou et al., 2024). As an immunomodulator, teplizumab exerts its role by targeting T-cells as well as enhancing regulatory T-cell activity and consequently supporting immune tolerance (Thakkar et al., 2023; Eerike & Konda, 2024). Curiously, while teplizumab has received specific approval for T1D, immunomodulatory doses are being studied for various other autoimmune diseases. For example, ablative chemotherapy

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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