

Ada Austin
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Dr. Jutta Heller

Particle-Based Delivery Systems for Antigen-Specific Tolerance and Symptomatic Reversal in Multiple Sclerosis (MS)

Abstract

During an immune response, cells of the immune system attack specific antigenic epitopes, causing an inflammatory response in the target tissue. In multiple sclerosis (MS) the immune system attacks the outer protective myelin tissue of the central nervous system (CNS), leading to chronic cognitive and mobility complications. This immune response broadens over time, expanding to different epitopes on the same or different antigen, leading to relapse and progressive neurodegeneration. Conventional disease-modifying therapies (DMTs) currently rely on broad immunosuppression, significantly increasing the risk of infection and reduced vaccine efficacy. Inverse vaccinations have recently emerged as a promising approach due to their capacity to re-establish immune tolerance to self-antigens rather than broadly suppressing immune function. This review focuses on the recent development of particle-based delivery systems for antigen-specific tolerance, resulting in the reduction of autoimmunity and symptomatic reversal of MS without immunological suppression. Due to the complex molecular and cellular framework of MS pathogenesis based on recently discovered multiepitope structures, antigen-induced tolerance needs further developmental research to address the challenge of epitope spreading. With future advancements in multiepitope-specific delivery, particle-based therapeutic inverse vaccination systems provide a transformative approach for inducing immune tolerance and symptomatic reversal of established MS while preserving protective immunity.