

A Comparative Analysis of Multimodal Imaging Techniques in the Diagnostics of Early Stage Alzheimer's Disease

Jordan Young

Professor

Humboldt University of Berlin

Unter den Linden 6, 10099 Berlin, Germany

David Baker

MD

University of Cambridge

The Old Schools, Trinity Ln, Cambridge CB2 1TN, United Kingdom

Kai Green

Dr. Sc

Johns Hopkins University

3400 N Charles St, Baltimore, MD 21218, United States

Cameron Jackson

PhD

University of Toronto

27 King's College Cir, Toronto, ON M5S 1A1, Canada

Abstract. The increasing prevalence of Alzheimer's disease (AD) globally underscores the urgent need for effective diagnostic modalities. This study conducts a comparative analysis of multimodal imaging techniques, specifically PET, MRI, and CT, to evaluate their efficacy in early-stage AD diagnosis. Through a systematic review of existing literature and a meta-analysis of diagnostic accuracy, we identified significant differences in sensitivity and specificity across the imaging modalities. PET demonstrated superior early detection capabilities compared to MRI and CT, potentially guiding timely therapeutic interventions. Our findings advocate for the integration of multimodal imaging strategies in clinical practice for enhanced diagnostic precision in Alzheimer's disease.

Keywords: Alzheimer's Disease, Diagnostic Imaging, Positron Emission Tomography, Magnetic Resonance Imaging, Computed Tomography, Neurodegeneration, Cognitive Decline, Early Diagnosis

Introduction

Alzheimer's disease (AD) is rapidly becoming one of the most significant global health challenges of the 21st century, with projections suggesting that the number of affected individuals will reach 150 million by 2050. The complexity of AD, characterized by

progressive cognitive decline and neurodegeneration, necessitates early and accurate diagnosis to improve patient outcomes and facilitate timely intervention. Although current therapeutic options are limited, early diagnosis can significantly enhance management strategies and patient quality of life. The primary challenge in diagnosing AD lies in its heterogeneous presentation and the overlapping symptoms with other neurocognitive disorders. Traditional clinical assessments often fall short in accurately identifying early-stage AD, thereby necessitating the use of advanced imaging techniques. This paper aims to explore the efficacy of three leading multimodal imaging approaches—Positron Emission Tomography (PET), Magnetic Resonance Imaging (MRI), and Computed Tomography (CT)—in diagnosing early-stage AD. Our systematic review seeks to dissect the diagnostic accuracy of these imaging modalities, provide a comparative analysis, and ultimately propose evidence-based recommendations for clinical practice. The structure of this paper is as follows: after the introduction, we will detail the methodology employed for the comparative analysis, present the results obtained, discuss the implications of our findings, and conclude with recommendations for future research and clinical applications.

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