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SPECIAL ARTICLE

Edentulousness effects on neuroimaging findings of the Brain: a narrative review

Efectos de la edentulidad en los hallazgos de neuroimagen del cerebro: una revisión narrativa

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Abstract

This narrative review examines the effects of edentulousness on neuroimaging findings in the brain. The aim is to provide an overview of the relationship between oral health status with a focus on dentation status and brain changes, as well as the impact of different prosthodontic treatments on brain activity. The review synthesizes findings from various studies investigating the association between edentulousness and neuroimaging outcomes. Our key findings included a significant correlation between the number of present teeth and the degree of brain atrophy, with tooth loss resulting in decreased volumes in cortical regions associated with sensory, motor, cognitive, and emotional functions, and increased volumes in subcortical regions. Implant-supported prostheses, specifically fixed dentures, demonstrate increased activation in the primary sensorimotor cortex and other brain regions involved in sensory and motor processing, leading to improved tactile perception and mastication functions. Complete dentures are associated with higher activity in the prefrontal cortex. Moreover, tooth loss, periodontal disease progression, and caries incidence serve as predictors of cognitive decline. These findings highlight the importance of maintaining good oral health for preserving brain health and cognition.

Key words: neuroimaging, brain atrophy, tooth loss, cognitive decline, oral health.

Resumen

Esta revisión narrativa examina los efectos del desdentado sobre los hallazgos de neuroimagen en el cerebro. El objetivo es proporcionar una visión general de la relación entre el estado de salud oral, centrándose en el estado de la dentadura, y los cambios cerebrales, así como el impacto de los diferentes tratamientos prostodóncicos en la actividad cerebral. La revisión sintetiza los hallazgos de diversos estudios que investigan la asociación entre el desdentado y los resultados de neuroimagen. Nuestros hallazgos clave incluyeron una correlación significativa entre el número de dientes presentes y el grado de atrofia cerebral, con la pérdida de dientes resultando en volúmenes disminuidos en regiones corticales asociadas con funciones sensoriales, motoras, cognitivas y emocionales, y volúmenes aumentados en regiones subcorticales. Las prótesis implantosoportadas, en concreto las fijas, muestran una mayor activación en el córtex sensoriomotor primario y en otras regiones cerebrales implicadas en el procesamiento sensorial y motor, lo que conduce a una mejora de la percepción táctil y de las funciones de masticación. Las dentaduras postizas completas se asocian a una mayor actividad en el córtex prefrontal. Además, la pérdida de dientes, la progresión de la enfermedad periodontal y la incidencia de caries sirven como predictores del deterioro cognitivo. Estos resultados ponen de relieve la importancia de mantener una buena salud bucodental para preservar la salud cerebral y la cognición.

Palabras clave: neuroimagen, atrofia cerebral, pérdida de dientes, deterioro cognitivo, salud bucodental.

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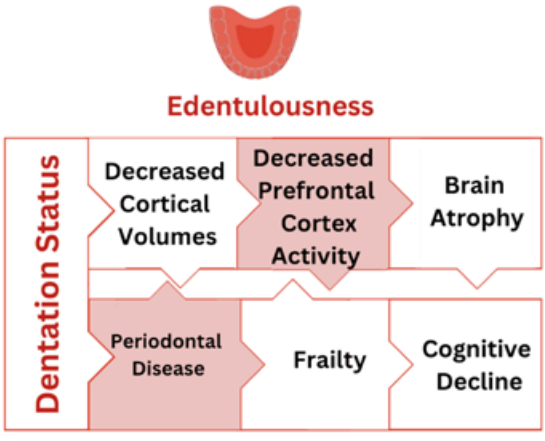
Introduction

There is growing evidence to suggest that there may be a link between oral health and brain health[1]. Several studies have found associations between poor oral health and an increased risk of certain cognitive disorders, including Alzheimer's disease and dementia[2]. Periodontal disease is a chronic inflammatory condition that affects the gums and supporting structures of the teeth. Several studies have found an association between periodontal disease and an increased risk of certain brain conditions[3]. Some studies have found a higher prevalence of periodontal pathogens in the brains of individuals with Alzheimer's disease, suggesting that oral bacteria may play a role in the development or progression of the disease[4]. Periodontal disease has been identified as a potential risk factor for stroke[5]. Studies have found that specific oral bacteria, such as Porphyromonas gingivalis associated with periodontal disease, can be detected in the brains of individuals with Alzheimer's disease[6]. However, the exact nature of the relationship and the underlying mechanisms are still under investigation. Magnetic Resonance Imaging (MRI) has significantly advanced our understanding of brain health by providing detailed images of the brain's structure and function[7]. MRI has revolutionized the field of neuroscience and significantly expanded our understanding of brain health, specifically in geriatrics[8]. By investigating the effects of edentulousness on neuroimaging findings of the brain, especially in MRI, this study aims to contribute to the existing literature, enhance our understanding of the relationship between oral health and brain health, and potentially inform clinical practice and interventions targeting both oral health and cognitive function in individuals with edentulousness.

Correlations of oral health and Cognition



While research in this area is still relatively limited, some studies have suggested potential associations between oral health factors and neuroimaging outcomes. But the relationships between these entities are complex. In the cross-sectional view, multiple shreds of evidence support the relationship between oral health and cognition. A study showed that a higher number of missing teeth and increased probing pocket depth were associated with lower cognitive scores[9]. Another study of 600 elderly individuals examined medical, dental, cognitive, and functional assessments. Cognitive impairment, oral self-care, and dental caries were interrelated. Oral self-care mediated the association between cognition and dental caries severity in community-dwelling older adults[10]. A prospective cohort study examined the association between periodontal disease and cognitive decline. Most indicators of adverse oral health were associated with cognitive impairment, with gingival inflammation being an independent predictor of cognitive decline[11]. Secondary analysis of NHANES III data examined the association between oral health and cognitive function. Worse oral health status was linked to poorer cognitive performance across all measures, even after adjusting for age[12]. A meta-analysis of 47 studies revealed that individuals with poor periodontal health, such as periodontitis, tooth loss, deep periodontal pockets, and alveolar bone loss, had 1.23 times higher risk of experiencing cognitive decline and 1.21 times more hazards of dementia. Tooth loss specifically increased the risk of cognitive decline (OR = 1.23) and dementia (HR = 1.13) independently. However, the quality of evidence was limited, and the possibility of reverse causality cannot be ruled out[13].

Edentulousness

As people age, they may experience tooth loss due to various factors, including long-standing oral health issues, gum disease, tooth decay, and the natural aging process[14]. Edentulousness is a dentistry term describing the state of being without teeth, causing difficulties in chewing, and speaking, aesthetic and psychological implications, and affecting a person's self-esteem and confidence. Edentulousness in geriatrics can have significant implications for oral health, overall health, and quality of life[15,16]. Edentulousness does not provide a comprehensive assessment of the overall oral health status, as other oral health problems, such as gum disease or oral infections, can still be present in individuals who have lost all their teeth[14-16].

Edentulousness and cognition decline

As part of the Prevention of Stroke and Dementia (PRESENT) project, researchers investigated how the number of lost teeth, an indicator of periodontal disease, relates to brain health in community-dwelling adults free from dementia or stroke. The PRESENT study included 438 participants aged 50 years and older who underwent dental examinations and brain CT scans. The results indicated that individuals with 6-10

lost teeth had a 2.3-fold increased risk of silent cerebral infarcts, while those with more than 10 lost teeth had a 4.2-fold increased risk[17]. Furthermore, a separate study of 41,380 men without cardiovascular disease or diabetes, periodontal disease and fewer teeth were associated with an increased risk of ischemic stroke over a 12-year follow-up period. Men with fewer than 25 teeth at baseline had a higher risk of stroke[18]. Having fewer remaining teeth and a longer edentulous period were associated with increased odds of having lower Mini-Mental State Examination (MMSE) scores. These findings suggest a link between tooth loss and cognitive function in older adults[19]. In a population-based cohort study in Singapore, data was collected from 1,047 older adults to examine the association between dentition status, frailty, and cognition. The results showed that having teeth was associated with lower odds of cognitive impairment and higher odds of being robust or pre-frail compared to being edentulous[20].

Edentulousness and neuroimaging findings

A primary cross-sectional study has shown that the number of present teeth was significantly correlated with the degree of brain atrophy[21]. In an animal model study, The objective of the study was to use high-resolution structural MRI (sMRI) to examine how tooth loss affects the structure of the brain in mice with different genetic backgrounds. The results showed that tooth extraction led to decreased volumes in cortical regions associated with sensory, motor, cognitive, and emotional functions, while subcortical regions exhibited increased volumes[22]. Complete denture treatment and wearing partial dentures lead to an increase in brain function activity in electroencephalograms (EEG)[23]. MRI studies have also revealed some pathways that describe the relationship between dentation status and brain changes. A study aimed to examine the cortical plasticity in patients with implant-supported prostheses using functional magnetic resonance imaging (fMRI). The results showed increased activation in the primary sensorimotor cortex, as well as other brain regions involved in sensory and motor processing, in patients with implant-supported fixed dentures. This suggests that implant-supported prostheses can restore sensory and motor feedback to the central nervous system, resulting in improved tactile perception and mastication functions similar to natural dentition[24]. Drawing upon the insights of some researchers, jaw movements have a valuable role in this complexity. Examination of cortical activity during jaw movement by fMRI showed that the primary sensory cortex (SI) and motor cortex (MI) were the primary activated sites in normal dentate people. In older people with normal teeth, teeth tapping induced brain activity at various foci, including the SI, MI, insula cortex, the supplementary motor cortex (SMC)/premotor cortex (PMA), cerebellum, thalamus, and basal ganglia. While edentate individuals have decreased activity in the SI, MI, Brodmann's area 6 (BA6), thalamus (ventral posteromedial nucleus, VPM), basal ganglia, and insular cortex. This decrease in S1/M1 activity in the OEd group was attributed to missing teeth, resulting in reduced periodontal afferents[25]. In a study involving four toothless individuals, the effects of different denture treatments on brain activity during gum chewing were investigated using fMRI. The results showed that the treatment with implanted-supported removable overdentures (IOD) significantly reduced brain activity in the prefrontal cortex compared to complete dentures (CD)[26]. Research on jaw-clenching reveals that implant-supported fixed dentures yield heightened levels of cerebral activity when juxtaposed with implant-supported overdentures and complete dentures. This disparity is particularly pronounced within brain regions intricately linked to primary sensory and motor functions[27]. These findings are also supported by EEG studies[28]. But the effects of dentures are not the same. Implant-retained overdentures may provide better sensory feedback and improve cognitive performance in edentulous patients compared to complete dentures[29].

Conclusion

In conclusion, this narrative review highlights the significant impact of edentulousness on neuroimaging findings in the brain. The number of present teeth is closely associated with the degree of brain atrophy, while tooth loss is linked to decreased volumes in cortical regions related to sensory, motor, cognitive, and emotional functions, as well as increased volumes in subcortical regions. Dentation status plays a role in brain changes, with implant-supported prostheses showing increased activation in the primary sensorimotor cortex and other brain regions involved in sensory and motor processing, leading to improved tactile perception and mastication functions. Furthermore, the use of complete dentures is associated with higher activity in the prefrontal cortex, and implant-supported fixed dentures result in heightened cerebral activity. Additionally, tooth loss, periodontal disease progression, and caries incidence serve as predictors of cognitive decline. These findings emphasize the importance of oral health in preserving brain health and cognition. Further research is warranted to better understand the underlying mechanisms and develop interventions to improve oral health outcomes and potentially mitigate cognitive decline in individuals affected by edentulousness.

Conflict of Interest

The authors declared that there is no conflict of interest.

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