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THE INTERPLAY BETWEEN ORAL HEALTH, SYSTEMIC FRAILTY, AND QUALITY OF LIFE IN THE AGING POPULATION: A COMPREHENSIVE REVIEW OF RECENT ADVANCEMENTS (2009–2025)

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ABSTRACT

The intersection of natural oral aging with severe conditions like periodontitis, chronic xerostomia, and tooth loss significantly compromises geriatric well-being and systemic health. National screening data from 2025 emphasizes this crisis, revealing that approximately 37 percent of the population under sixty has already experienced tooth loss, indicating a broader global public concern. This systematic review comprehensively evaluates the precise impact of physiological aging on hard oral structures, edentulism-related frailty, microbiota balance, and psychosocial prosthetic rehabilitation outcomes. The methodology involved an exhaustive screening and qualitative synthesis of contemporary scientific literature, including clinical trials and observational analyses published between 2009 and 2025. The findings indicate that senescence induces cumulative alveolar bone depletion, enamel thinning, and salivary gland hypofunction, which collectively increase overall malnutrition risks and poor nutritional intake. Crucially, edentulism directly accelerates physical frailty, particularly in older individuals with fewer than 20 functional teeth, while altering oral-gut microbial homeostasis. Conversely, timely oral rehabilitation via implants or removable dentures restores masticatory efficiency and psychological wellness, substantially upgrading quality of life. The main conclusion asserts that severe oral deterioration is largely preventable; integrated overall geriatric care prioritizing the preservation of 20 remaining teeth and vital long-term prosthetic restoration is paramount to mitigating physical decline.

Keywords: *Aging, Oral Health, Tooth Loss, Alveolar Bone Loss, Xerostomia, Frailty, Quality of Life, Geriatric Dentistry.*

INTRODUCTION

Aging is a complex, irreversible biological process involving progressive physiological declines and structural alterations across various organs, including the oral cavity. As global life expectancy rises, geriatric oral health has emerged as a crucial priority in modern dentistry. Ideal dental care for the elderly aims to maintain optimal oral function, which is essential not only for mastication and speech but also for safeguarding systemic health and overall well-being. However, age-related anatomical changes continuously compromise both hard and soft tissues. Enamel thinning, secondary dentin deposition, salivary gland atrophy causing *xerostomia*, reduced periodontal vascularity, and cumulative alveolar bone loss present severe diagnostic and therapeutic hurdles in everyday clinical practice. Furthermore, benign mucosal variations on the tongue frequently mimic serious pathological conditions, demanding high diagnostic precision from clinicians. When these physiological transformations are compounded by inadequate daily oral hygiene, the risk of rapid oral health deterioration

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increases dramatically. Consequently, maintaining functional dentition and healthy oral mucosa in the elderly becomes increasingly difficult, disrupting the ideal standard of geriatric dental care and creating a widening gap between clinical objectives and practical outcomes (Alfaer et al., 2025; Leung & Chu, 2022; Miteva & Panov, 2023)

The high prevalence of *edentulism*, or tooth loss, among the elderly represents one of the most critical gaps between ideal oral health standards and real-world clinical realities. Conventionally, tooth loss has been treated as a localized issue affecting aesthetics and chewing efficiency. However, emerging evidence reveals that missing teeth trigger systemic health declines, severely impacting the general functional capacity of older individuals. Specifically, individuals with fewer than twenty teeth face a significantly elevated risk of physical frailty and systemic vulnerability. This breakdown in oral integrity disrupts the complex *oral-gut* axis, as shifts in oral microbiota composition alter gut microbial balance, leading to systemic inflammation and metabolic dysregulation. Despite the clear systemic dangers associated with tooth loss, routine geriatric care often fails to integrate comprehensive oral health evaluations into broader frailty risk assessments. This clinical disconnect leaves many elderly individuals without timely dental rehabilitation, allowing preventable physical decline to accelerate. Addressing this oversight requires shifting the medical paradigm toward recognizing functional oral health as an indispensable pillar of systemic vitality in aging populations (Albalawi et al., 2025; Dibello et al., 2021; Sathvika, 2026)

In field settings, the research subject—consisting of geriatric patients requiring comprehensive oral health management—faces significant obstacles in accessing appropriate dental interventions. While oral rehabilitation through removable dentures or dental implants can restore masticatory function and improve *Oral Health-Related Quality of Life*, the research subject frequently encounters barriers related to limited dental health literacy, restricted mobility, and inadequate access to specialized dental services. Field observations reveal that the research subject often delays seeking professional care until severe functional impairment or severe discomfort occurs, exacerbating both oral and systemic health risks. Furthermore, routine clinical management for the research subject often focuses narrowly on symptomatic relief rather than addressing underlying biological mechanisms such as *xerostomia*, alveolar resorption, and gut microbiome dysbiosis. This reactive treatment model fails to provide long-term functional stability or mitigate frailty risks. Consequently, the research subject remains particularly vulnerable to rapid health deterioration, highlighting an urgent need for proactive, patient-centered interventions that combine preventive oral care, functional restoration, and systemic health monitoring in community and institutional settings (Botelho et al., 2022; Patel et al., 2021; Ranjith et al., 2024)

While existing literature extensively documents isolated physiological changes in the aging mouth, a significant gap remains regarding how these local oral transformations systematically interact with distant organ systems. Most previous studies have investigated age-related tooth loss, salivary dysfunction, or periodontal degradation in isolation, treating them as localized dental conditions rather than systemic disease drivers. Consequently, there is a lack of integrated clinical frameworks that connect oral tissue loss directly to systemic physical frailty through specific biological pathways like the *oral-gut* axis. Traditional geriatric dentistry frequently overlooks the quantitative relationship between remaining tooth count, microbial translocation, and functional decline, leaving clinicians without standardized metrics to evaluate systemic risk during routine oral examinations. Furthermore, research examining how prosthetic rehabilitation modulates systemic inflammation and gut microbial stability remains limited. This empirical gap prevents healthcare providers from developing holistic, cross-

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disciplinary management protocols. Bridging this knowledge deficit is essential for advancing geriatric medicine, moving beyond basic tooth replacement toward comprehensive interventions that preserve systemic health and functional independence in aging individuals.

To bridge these clinical and empirical gaps, this research introduces an innovative, multi-system synthesis framework that redefines geriatric oral healthcare. The primary novelty of this study lies in establishing a quantitative, mechanistic bridge linking *edentulism*, *oral-gut* axis dysbiosis, and physical frailty risks specifically tailored for geriatric care, without restricting the scope to a specific school name or academic year. Rather than treating tooth loss solely as a localized mechanical defect, this inquiry frames functional dentition as a vital biomarker for systemic health and functional longevity. By systematically analyzing recent literature on microbial shifts, nutritional decline, and frailty progression, the study offers a fresh, interdisciplinary perspective that integrates oral rehabilitation directly into general geriatric risk assessment protocols. This innovative approach provides clinicians with actionable insights to optimize preventive, restorative, and supportive care strategies. Ultimately, this research elevates the role of dentistry within general medicine, equipping healthcare professionals with evidence-based frameworks to reduce physical frailty, preserve systemic health, and enhance overall quality of life for the aging population.

RESEARCH METHODS

The literature search was conducted across the PubMed, Scopus, and Google Scholar databases using the keywords 'oral senescence', 'tooth loss AND frailty', and 'oral-gut axis' to ensure comprehensive coverage of literature published between 2009 and 2025. This literature review is based on a methodological analysis of 15 scientific papers (2009–2025). Broadly, the methodologies employed in these journals can be classified into four primary technical domains:

1. **Clinical Observational and Epidemiological Methodology**
   Most of the journals utilized cross-sectional study designs to map real-world conditions within the elderly population.
   - **Sampling Procedures:** The majority employed purposive sampling or total sampling within specific populations, such as patients at the Universitas Hasanuddin Dental Hospital (RSGM) (n=30 for complete denture/GTL studies; n=20 for knowledge-based studies) and residents of the Tresna Werdha Nursing Home (Nurfianti et al., 2024).
   - **Survey Instruments:** Structured questionnaires were used to measure the level of dental health knowledge and behavior. Specifically for quality of life, psychometric instruments such as the OHIP-14 (Oral Health Impact Profile) were utilized, measuring seven dimensions: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap.
   - **Statistical Analysis:** Data were processed using the Chi-Square test to examine relationships between variables (e.g., the correlation between xerostomia and quality of life) and simple linear regression tests to observe the impact of interventions (e.g., the effect of complete dentures on OHIP-14 scores).
2. **Radiographic and Morphometric Methodology**
   To measure changes in hard tissues (bone), the relevant journals utilized imaging analysis.
   - **Radiographic Technique:** The use of Digital Panoramic Radiography to evaluate the entire dental arch.

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- **Alveolar Bone Loss (ABL) Measurement Procedure:** A study by Khoirunisa et al. (2025) employed a measurement method from the Cemento-Enamel Junction (CEJ) to the Alveolar Crest on the mesial and distal sides of the first molar. The resulting figures were then converted to determine the percentage of chronic bone loss. The phenomenon of radiographic alveolar bone loss found in the elderly (Khoirunisa et al., 2025) is biologically reinforced by molecular changes in periodontal cells that intensify responses to the oral microbiota and mechanical stress (Huttner et al., 2009).

3. Molecular Biology and Microbiome Methodology

This represents the most technical and in-depth methodology found in recent international journals (2024–2025).

- **Microbiota Analysis (Oral-Gut Axis):** A study by Dong et al. (2025) utilized animal models (C57 mice) that underwent molar extractions.
  - **16S rRNA Sequencing:** Used to identify changes in bacterial communities within saliva and fecal samples.
  - **Metagenomic Sequencing:** To analyze the genetic functions of altered bacteria (such as the increase in *Proteobacteria* and the decrease in *Bacteroidota*).
- **Cellular Analysis:** The study by Huttner et al. (2009) performed data synthesis at the cellular level, analyzing the differentiation of osteoblasts and osteoclasts, as well as the increased secretion of pro-inflammatory cytokines due to mechanical stress in geriatric periodontal tissues.

4. Meta-Analysis and Systematic Review Methodology

Several journals employed secondary data synthesis techniques to provide large-scale conclusions.

- **PRISMA Protocol:** Utilized by Zhang et al. (2025) in a meta-analysis involving 36,406 participants.
- **Newcastle-Ottawa Scale (NOS):** An instrument used specifically to assess the methodological quality of the observational studies included in the meta-analysis.
- **Odds Ratio (OR) Analysis:** Used to quantitatively calculate relative risk; for instance, finding that individuals with ≤20 teeth have a 1.99-fold higher risk of frailty.

The methodological framework within the reviewed literature encompasses a broad spectrum, ranging from molecular analysis (16S rRNA sequencing) to elucidate the oral-gut axis, to psychometric methods (OHIP-14) for assessing patients' subjective perceptions. The application of digital radiography using the Schei method provides objective standardization in evaluating alveolar bone degradation, while meta-analyses utilizing the Newcastle-Ottawa Scale (NOS) ensure the validity of findings regarding systemic frailty risks in the geriatric population.

Final Synthesis Procedure

In developing this literature review, an Integrative Analysis approach was employed to synthesize the 15 selected journals. The process involved a triangulation of three distinct data dimensions:

- **Objective Data:** Findings from radiographic imaging (e.g., alveolar bone loss) and clinical microbiological examinations (e.g., microbiome sequencing).
- **Subjective Data:** Patient-reported outcomes concerning the perceived quality of life (OHRQoL) among the elderly.

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- **Theoretical Data:** Cellular aging mechanisms (senescence) that serve as the underlying framework to explain the correlation between objective clinical manifestations and subjective patient experiences.

RESULTS AND DISCUSSION

Results

Table 1. Summary Table Of Technical Methods

No	Author & Year	Study Design	Criteria & Sample Size	Technical Methods & Specific Instruments
1	Kamur et al. (2025)	Cross-sectional	30 edentulous patients (aged 60-75 years)	OHIP-14 Questionnaire, Simple Linear Regression Analysis (SPSS).
2	Eva et al. (2023)	Quantitative Survey	32 elderly individuals at PPSLU Mappakasunggu	Purposive Sampling Technique, Chi-Square Test for the correlation between Xerostomia & Quality of Life.
3	Dong et al. (2025)	In-Vivo Animal Model	C57 mice (Tooth Loss Model)	16S rRNA & Metagenomic Sequencing; Pearson correlation analysis (Oral-Gut Axis).
4	Khoirunisa et al. (2025)	Radiographic Observational	Secondary Data (Panoramic Radiographs)	Schei Method (measurement of CEJ to Alveolar Crest distance) on First Molars.
5	Zhang et al. (2025)	Systematic Review & Meta-Analysis	22 Articles (36,406 participants)	PRISMA Protocol, Newcastle-Ottawa Scale (NOS), Heterogeneity Test (I2 statistic).
6	Ongko et al. (2025)	Narrative Review	Literature study (Review)	Comparative analysis of histological changes in salivary glands (atrophy & fibrosis).
7	Taue et al. (2024)	Clinical Comparative	227 elderly patients (Implants vs. Dentures)	Evaluation of occlusal function, number of functional teeth, and Logistic Regression.
8	Julkunen et al. (2024)	Clinical Examination	303 LTCF residents (Finland)	Oral Disease Burden (ODB) Index, dietary assessment (soft/pureed food) & speech clarity.
9	Chan et al. (2024)	Clinical Review	Elderly patients with tooth wea	Assessment using the Smith & Knight Tooth

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				Wear Index (TWI) & 38% SDF effectiveness.
10	Wahyukundari (2024)	Cross-sectional	Elderly residents in limestone mining areas	OHI-S Index (Greene & Vermillion); Analysis of health behavior characteristics.
11	Nurfianti (2024)	Clinical Descriptive	Elderly residents at Tresna Werdha Nursing Home	Intraoral clinical examination for the identification of Normal Tongue Variations.
12	Lubis et al. (2025)	Descriptive Survey	20 prosthodontic patients at RSGMP	Total Sampling technique, bivariate analysis (cross-tabulation) regarding tooth loss knowledge.
13	Ziyati & Sidqui (2024)	Anatomical Review	Literature study (Review)	Analysis of micro-structural changes (secondary dentin, cementum, & connective tissue).
14	Huttner et al. (2009)	Biological Review	Cellular & molecular studies	Analysis of osteoblast/osteoclast proliferation & pro-inflammatory cytokine secretion in the elderly.
15	Bolukbasi (2024)	Clinical Review	Radiological & Clinical Review	Integration of radiographic imaging data for the detection of root caries and periodontal disease.

The literature review of the 15 selected studies categorized the findings into four primary, interconnected domains:

1. Anatomical and Physiological Changes of Oral Tissues

- **Alveolar Bone Loss (ABL):** Radiographic studies focusing on the first molars demonstrated a significant increase in alveolar bone loss associated with advancing age ($p<0.05$). Functional measurements on the mesial and distal aspects indicated a higher average ABL in the elderly group. Notably, a higher prevalence was observed in males, which potentially correlates with lifestyle factors and lower adherence to oral hygiene protocols.
- **Salivary Gland Hypofunction (Xerostomia):** The atrophy of acinar tissue and its replacement by connective tissue lead to a drastic decline in salivary flow rates. Xerostomia prevalence reached 100% in respondents aged 75–90 years, significantly surpassing the 60–74 age group. Although aging causes gradual atrophy of the salivary glands, xerostomia in the elderly is often multifactorial. The use of systemic medications with anticholinergic activity (polypharmacy) is frequently the primary triggering factor that exacerbates salivary hypofunction,

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leading to swallowing difficulties (dysphagia) and compromised nutritional status (Ongko et al., 2025).

- **Normal Tongue Variations:** In the elderly population residing in nursing homes, the prevalence of normal tongue variations is remarkably high. The most frequently identified types are fissured tongue and coated tongue (Nurfianti et al., 2024).
- **Tooth Wear:** Enamel thinning and the increase of sclerotic dentin clinically manifest as dentin hypersensitivity, which interferes with eating comfort in the elderly. Beyond caries, tooth wear is a prevalent condition that not only compromises aesthetics but also frequently triggers persistent dentin sensitivity. Clinical management using 38% Silver Diamine Fluoride (SDF) has proven effective in reducing hypersensitivity on exposed root surfaces within the geriatric population (Chan et al., 2024).

2. **Tooth Loss (Edentulism) and Systemic Frailty**
   - **Correlation with Frailty:** Recent meta-analyses indicate that elderly individuals with ≤ 20 teeth have a 1.99 times higher risk of experiencing physical frailty (OR 1.99; 95% CI: 1.70-2.32) compared to those with a higher tooth count (Zhang et al., 2025).
   - **Standardization of Oral Frailty:** The definition of oral frailty has now been standardized. An elderly individual is considered to have this condition if they meet at least two of the following criteria: a soft/pureed food diet, presence of food debris in the mouth, difficulty opening the mouth during examination, speech lack of clarity, or complaints of xerostomia (Julkunen et al., 2024). Furthermore, the latest evidence reinforces that individuals with 20 teeth or fewer face twice the risk of physical frailty compared to those with more teeth (OR 1.99; Zhang et al., 2025).
3. **The Oral-Gut Microbiota Axis**
   - **Microbial Community Shifts:** The loss of molar teeth triggers a significant shift in bacterial communities, characterized by an increase in *Proteobacteria* within the oral cavity and a reduction in *Muribacter*.
   - **Systemic Impact on Intestinal Homeostasis:** Recent research reveals the existence of an oral-gut axis, where oral dysbiosis caused by tooth loss correlates with intestinal microbiota imbalances—specifically an increased Firmicutes/Bacteroidota ratio. These findings suggest that dental integrity is crucial for maintaining systemic digestive homeostasis (Dong et al., 2025).
4. **Oral Hygiene Status and Periodontal Health**
   - **Periodontal Cellular Response:** At the molecular level, elderly periodontal cells exhibit an increased secretion of pro-inflammatory cytokines in response to the oral microbiota. This mechanism accelerates the destruction of periodontal attachment, even in the absence of severe systemic diseases (Huttner et al., 2009).
   - **Oral Hygiene in Specific Environments:** Studies involving elderly residents in limestone mining areas demonstrate a significant correlation between dental maintenance behavior and Oral Hygiene Index Simplified (OHI-S) status. Environmental factors, coupled with a lack of knowledge regarding tooth loss prevention, remain the primary obstacles (Wahyukundari et al., 2024; Lubis et al., 2025).
5. **Effectiveness of Oral Rehabilitation on Quality of Life**
   - **Impact of Removable Complete Dentures (RCD):** The use of RCD significantly enhances the quality of life in edentulous patients (p=0.001). Linear regression

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analysis indicates that RCD contributes 34.7% to the improvement of OHIP-14 scores, particularly within the dimensions of masticatory comfort and speech function (Kamur et al., 2025).

- **Dental Implants in the Elderly:** Geriatric patients seeking implant treatment tend to exhibit better oral functional status and higher health motivation compared to those opting for conventional dentures. Implants provide superior occlusal stability, which directly impacts nutritional status (Taue et al., 2024).

Variable	Key Findings	Significance/Statistics
Frailty	Reduced tooth count increases the risk of physical frailty.	OR 1,99 (Zhang, 2025)
Quality of Life	Installation of Removable Complete Dentures (RCD) improves OHRQoL.	p=0.001 (Kamur, 2025)
Xerostomia	Age > 75 years presents a high risk for dry mouth symptoms.	100% Prevalence (Eva, 2023)
Microbiome	Tooth loss triggers alterations in gut bacterial composition.	Firmicutes Shift (Dong, 2025)
Alveolar Bone	Decreased bone density observed at the first molar site.	Age & Sex Dependent (Khoirunisa, 2025)

Discussion

The aging of the oral cavity is not merely a chronological process; rather, it represents a manifestation of accumulated molecular alterations, tissue degeneration, and the long-term impact of health behaviors throughout the lifespan. Based on the synthesis of the reviewed literature, three primary pillars elucidate the complexity of oral health in the elderly:

1. Biological Mechanisms of Oral Tissue Degeneration

Findings in the literature confirm that cellular aging significantly alters the structure of the periodontium. While natural aging does not directly cause extreme periodontal attachment loss, alterations at the molecular level—such as decreased osteoblast proliferation and heightened sensitivity to pro-inflammatory cytokines—render the supporting tissues of the elderly more susceptible to plaque-induced destruction (Huttner et al., 2009). This elucidates why alveolar bone loss (ABL) is found to increase cumulatively with age, as evidenced in radiographic studies (Khoirunisa et al., 2025). This condition is further exacerbated by salivary gland atrophy, which leads to xerostomia. The decline in salivary flow rate is not merely an issue of comfort; it represents a critical risk factor for root caries and candidiasis. The loss of the protective functions of saliva accelerates the decay of teeth that have already undergone enamel thinning due to years of accumulated tooth wear (attrition and erosion).

2. Tooth Loss as a Determinant of Systemic Health (Oral-Gut Axis)

One of the most crucial points in this discussion is the correlation between tooth count and overall systemic health. The finding that individuals with ≤ 20 teeth face nearly twice the risk of physical frailty (Zhang et al., 2025) reinforces the concept of the oral cavity as a gateway to systemic health. The loss of molar teeth, in particular, triggers a dietary shift toward soft, low-fiber foods, which subsequently disrupts the balance of the gut microbiota. The phenomenon of taxonomic bacterial shifts (*Proteobacteria* and *Firmicutes*) following tooth loss suggests a biological mechanism whereby poor oral health can trigger systemic inflammation through the oral-gut axis (Dong et al., 2025). This shifts the paradigm from viewing tooth loss merely as an aesthetic concern to recognizing it as a serious medical issue.

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3. The Role of Oral Rehabilitation in Breaking the Cycle of Declining Quality of Life

The psychosocial impact of an edentulous condition is substantial, ranging from speech difficulties to a marked decline in self-confidence. However, study results demonstrate that prosthetic interventions, such as Removable Complete Dentures (RCD), are capable of providing tangible improvements in quality of life by enhancing masticatory function (Kamur et al., 2025). Interestingly, there is a distinct profile among elderly individuals who opt for dental implants; they tend to possess higher health motivation and more stable oral function compared to conventional prosthesis users (Taue et al., 2024). This suggests that access to advanced dental technology can assist the elderly in maintaining oral functions that more closely approximate normal physiological conditions, which in turn serves to prevent the onset of oral frailty.

4. Educational and Environmental Challenges

Despite the availability of clinical solutions, significant challenges persist regarding health literacy and environmental factors. The limited understanding among the elderly regarding the importance of replacing missing teeth, coupled with environmental influences on oral hygiene (as seen in specific industrial or mining contexts), suggests that clinical approaches must be integrated with robust community education programs. Retaining at least 20 functional teeth into old age should be the primary target in geriatric public health management. Furthermore, while the link between tooth loss and gut microbiota disruption has been identified in animal models (Dong et al., 2025), longitudinal human studies are urgently needed. Such research is essential to evaluate whether prosthetic rehabilitation, such as implants or dentures, can effectively restore gut microbiota balance and improve systemic outcomes.

CONCLUSION

The comprehensive review concludes that the impact of biological aging on oral health is a cumulative degenerative process driven by structural tissue changes and the long-term accumulation of pathological factors. Retaining a minimum threshold of functional natural teeth is a vital systemic health indicator, as extensive tooth loss correlates with physical frailty, malnutrition risk, and disruptions along the oral-gut microbiota axis. Timely oral rehabilitation, particularly through dental implants and removable complete dentures, significantly restores masticatory function, occlusal force, and overall oral health-related quality of life for geriatric patients. Furthermore, addressing low health literacy through early preventive strategies and targeted education is essential to prevent severe dental hard tissue destruction. Ultimately, integrating comprehensive geriatric dental management into primary healthcare frameworks is necessary to maintain systemic well-being, functional independence, and psychological vitality in the aging population.

Future researchers are encouraged to conduct prospective longitudinal cohort studies across diverse geographic populations to track the long-term systemic impacts of tooth loss and prosthetic interventions in elderly individuals. Subsequent investigations should explore the molecular mechanisms governing the oral-gut axis, specifically analyzing how variations in molar occlusion influence gut microbiome diversity and systemic inflammatory markers over time. Researchers ought to design clinical trials comparing the efficacy of conventional prostheses against implant-supported rehabilitations while incorporating standardized biomarkers for sarcopenia, cognitive decline, and nutritional status. Additionally, future studies should evaluate the implementation of digital oral health literacy programs and tele-dentistry interventions tailored specifically for frail geriatric cohorts. Integrating multi-disciplinary

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approaches involving dentists, geriatricians, and nutritionists will provide deeper insights into developing personalized, preventive oral care protocols that promote healthy aging and sustainable quality of life.

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