Review

Oral health of centenarians and supercentenarians

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Abstract: There are many studies on the homebound and institutionalized elderly; however, few studies focus on centenarians and supercentenarians, i.e., people aged 100 and 110 years, respectively. Due to the demographic changes, the population of centenarians is set to increase more than that of other age groups. Therefore, this article aims to review the available literature regarding how oral health might display in this age group and highlight aspects necessitating further research. Oral health, oral health-related quality of life, saliva, and the oral microbiome were emphasized in this study. Most papers relevant to the research questions were excluded because the mean age of participants was <100 years. Only two papers were found on centenarians' oral health status and saliva and no studies were found focusing on the oral health-related quality of life or oral microbiome. The reviewed studies demonstrate that centenarians presented with good oral mucosal conditions, dental conditions, and general health. The present literature is insufficient to come to a definite conclusion regarding how aging affects the oral health of centenarians and supercentenarians. The limited available research indicates that centenarians display better oral health than other individuals in their respective birth cohorts.

Keywords; centenarians, longevity, microbiome, oral health

Introduction

Demographic changes in industrialized countries reveal a large and increasingly diverse population of older adults. There is a time period of >35 years between the so-called younger elderly and oldest old [1]. Individuals born after the year 2000 will likely live ≥ 100 years [2]. Data from the national census in Europe (Eurostat database) reveal an average of 17.3 centenarians per 100,000 people, with the highest percentage of centenarians in France, Italy, and Greece and 72% of centenarians in Europe live in private households [3]. The factors of centenarians' longevity and health have long been of interest to the scientific community, resulting in a considerable amount of research. A high percentage of centenarians (89%) remain functionally independent until their mid-90s [4,5]. They manage to evade life-threatening conditions such as cancer and circulatory diseases and instead face an acute physical decline at the end of their lives. According to the International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10), the main causes of death in centenarians are pneumonia and "old age" (i.e., frailty) [6]. Hereditary and environmental factors influenced by a wide range of lifestyles are pivotal for achieving extreme longevity. The complex interplay between microbiota and the host genome might also be relevant because a quarter of the variations during the human lifespan can be attributed to genetic factors [7]. Several genetic polymorphisms are associated with the exceptional longevity of individuals aged ≥ 85 years; some of these are linked to cardiovascular health and metabolism [8,9].

Regarding oral health, the increasing number of elderly people who retain their natural teeth presents a challenge in preventive and restorative

dental care [10]. Continuous collection of data such as those from national oral health surveys are able to illustrate oral health development with a significant increase in relevant data pertaining to the elderly population. The German Oral Health Study first included the elderly population in 2015, resulting in oral health data for two separate age groups: younger elderly (65 to 74 years) and older elderly (75 to 100 years) [11]. This data highlights the increased importance of treating age-related oral changes concerning the whole dentition, mucosa, tongue, and alveolar bone. However, the rapid demographic change reveals a lack of caregivers' awareness regarding the importance of oral health and its maintenance in the elderly population. This literature review aims to provide an overview of the current status of oral health in centenarians and supercentenarians, highlights aspects necessitating further research, and discusses how the oral health of this population might be achieved.

Materials and Methods

Literature search, study selection, and data extraction were performed by two independent examiners (C.F. and C.S.). The search strategy of this review was defined according to the PRISMA statement [12] and the inclusion and exclusion criteria are shown in Table 1. According to this criteria, the Cochrane Library and MEDLINE (PubMed, NLM) were electronically searched from November 2018 until June 2019 (the search terms used are shown in Table 2). Full-text manuscripts were obtained for all eligible articles and reference articles were manually searched to identify additional suitable articles. Oral health, oral health-related quality of life, saliva, and the oral microbiome were emphasized in this study. The publications were sorted according to their subject and classified into the above mentioned categories. Data extraction for qualitative analysis was performed for the included studies.

Results

Literature identification

The process of selecting the studies for the literature review is presented in Fig. 1. The electronic search identified 4,488 articles, with no additional articles retrieved via manual search. After removing duplicates, there were 3,924 articles and 310 were excluded because they were published in a language other than English. Of the remaining 3,614 articles, 2,537 were excluded because they were irrelevant and 1,077 were excluded because the participants aged <100 years. Only two studies fit the eligibility criteria and were included in this review (one study from the USA and one from P. R. China) [5,13]. Both studies matched the oral health criterion and one matched the salivary parameter criterion. There were no studies examining the oral health-related quality of life or oral microbiome of centenarians.

Characteristics of included studies

The characteristics of the included studies are presented in Table 3. The publication by Kauffman et al. from the New England Centenarian Study presented oral health data from 64 centenarians, 437 centenarian offsprings, and 229 offspring controls [5]. They hypothesized that because centenarians and their offsprings demonstrate a delay in age-related diseases when compared with individuals in their respective birth cohorts, they might also present better oral health. Data were collected using a 13-item self-reported oral health questionnaire that revealed 34.9% centenarians still had more than half of their teeth and 36.5% centenarians were edentulous compared with other individuals of their birth cohort, 46% of whom were edentulous

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Table 1 Eligibility criteria

Inclusion criteria	Exclusion criteria
Indexed papers and reviews written in English	Not indexed and original papers not written in English
Study subjects are centenarians or supercentenarians	Study subjects aged <100 years
Assessment of oral health data	No assessment of oral health data
Assessment of oral health-related quality of life data	No assessment of oral health-related quality of life data
Assessment of salivary parameters	No assessment of salivary parameters
Assessment of oral microbiome	No assessment of oral microbiome

Table 2 List of search strategies used in PubMed (MEDLINE)

1	("centenarians" [All Fields] OR "Aged, 80 and over" [Mesh]) AND "oral health" [MeSH])
2	("centenarians" [All Fields] OR "Aged, 80 and over" [Mesh]) AND ("oral" [All Fields] AND "health" [All Fields] OR "oral health" [MeSH]) AND ("quality" [All Fields] AND "life" [All Fields] OR "quality of life" [MeSH])
3	("centenarians" [All Fields] OR "Aged, 80 and over" [Mesh]) AND ("saliva" [All Fields] OR "saliva" [MeSH])
4	("centenarians" [All Fields] OR "Aged, 80 and over" [Mesh]) AND (("oral" [All Fields] AND "microbiome" [All Fields]) OR "Mouth/microbiology" [MeSH] OR ("oral" [All Fields] AND "microbiota" [MeSH]))

Fig. 1 PRISMA flowchart detailing study selection

between the ages of 65 and 74 years. In this study, centenarians and their offsprings displayed better oral and general health than other individuals in their respective birth cohorts. Furthermore, the participants' good oral health was associated with the absence of hypertension, diabetes, myocardial infarction, and stroke [5]. Qiu et al. studied mucosal conditions and related factors in 140 Uyghur centenarians [13]. In this study, oral mucosa, mucosal exfoliative cells, saliva, and blood were collected. Salivary IgA, IgM, and IgG; complement factors C3 and C4; NO; ten trace elements; sex hormones; a thyroid hormone; and osteocalcin were analyzed. In terms of the mucosal status, 64.29% centenarians had normal labial, buccal, palatal, and gingival mucosae. Abnormalities were mainly classified as vascular nevus patches and senile plaques. The exfoliative cell characteristics were similar to those of the elderly Chinese reference population [13].

Discussion

Oral health

The oral health status of centenarians as reported by Kaufman et al. [5] shows exceptionally favorable results compared with other individuals of their birth cohort. Due to the lack of other evidence in this age group, further comparisons can only be made with younger cohorts. The 36.5% edentulism rate among centenarians reported by Kaufman et al. [5] is in midfield when considering data reported for other elderly individuals in countries with comparable demographics. For instance, the Adult Dental Health Survey conducted in UK in 2009 reported an edentulism rate of 47% among individuals aged >85 years [14]. Individuals aged 75 to 100 years examined in the fifth German Oral Health Study exhibited an edentulism rate of 32.8% [Jordan et al., Fünfte Deutsche Mundgesundheitsstudie

Table 3 Characteristics of included studies

Author (year) (Reference)	Study aim (as reported)	Method	Centenarian participants		Outcome measures	Relevant findings
			Number	Age range in years (Mean)		
Kaufman (2014) (5)	To determine whether oral health is better in centenarians than in a birth cohort-matched sample and to compare oral health in centenarian offspring with a case-controlled reference sample	Cross-sectional Survey (self-reported data)	64	102-110 (106.4)	<ul style="list-style-type: none"> - Number of remaining natural teeth - Edentulous rate - Oral health status - Oral health habits 	<ul style="list-style-type: none"> - The edentulous rate of centenarians (36.5%) was lower than their birth cohort (46%) when aged 65-74 years - Compared with centenarian offspring, the referent cohort was more likely to be edentulous, less likely to have all or more than half of their teeth, and less likely to report excellent/very good oral health
Qiu (2000) (13)	To investigate the condition of the oral mucosae in Xinjiang Uygur centenarians and explore some related factors	Cross-sectional study	140	100-135 (n/a)	<ul style="list-style-type: none"> - Oral mucosal conditions - Salivary Ig, C, NO, and trace elements 	<ul style="list-style-type: none"> - Most centenarians (64.29%) had normal labial, buccal, palatal, and gingival mucosae - Abnormal changes in mucosae were mainly vascular nevus patches and senile plaques - Centenarians with normal mucosae had higher levels of molybdenum in their saliva. No other significant differences in salivary elements were observed

(DMS V), 522, Institut der Deutschen Zahnärzte, Deutscher Zahnärzte Verlag, 2016]. Results from the National Health and Disability Survey in France analyzing those aged ≥ 60 years show that 28.84%-53.96% of these individuals have lost all or nearly all their teeth (depending on whether they live at home or are institutionalized) [15]. Data from the Australian National Survey of Adult Oral Health 2004-2006 show an edentulism rate of 35.7% for those aged ≥ 75 years [Slade et al., Australia's dental generations, The National Survey of Adult Oral Health 2004-06, 83, Australian Institute of Health and Welfare, 2007] and the United States National Health and Nutrition Examination Survey estimates the prevalence of edentulism of those aged ≥ 75 years to be 31.3% [Dye et al., Trends in Oral Health Status: United States, 1988-1994 and 1999-2004, 76, National Center for Health Statistics, 2007]. In some of these cases, the rate of edentulism is higher than in the centenarian population. However, this discrepancy is small when considering the age differences of the participants as well as the quality of and their access to health care during their lifetime.

The results of this centenarian study are limited because the data analysis was based on self-reports. To date, no clinical evaluation exists. Providing objective results on the oral health status of centenarians, including information about the burden of other important oral diseases like caries and periodontitis must therefore be the aim of further studies.

Oral health-related quality of life

Generally, the oral health-related quality of life of the elderly is assessed using the Geriatric Oral Health Assessment Index, which identifies oral dysfunction, pain, and psychosocial effects linked to oral diseases [16,17]. Although the studies focused on the oral health-related quality of life included older participants or institutionalized elderly, no information on the oral health-related quality of life of centenarians was included. In general, poor oral health affects the individuals' quality of life [18]. Due to their need for high-dependency care, the oral health-related quality of life of the institutionalized elderly is lower than that of the independent elderly living in their households and is positively associated with better oral health [19]. Previous studies have consistently shown that institutionalized older adults with dementia or Alzheimer's disease have poorer oral health including higher amounts of plaque and tooth decay than institutionalized elderly without dementia [20]. Oral health-related quality of life was reported to be better in patients with normal cognitive function [21]. Therefore, the oral health-related quality of life of centenarians who are rarely affected by dementia or Alzheimer's disease might be of significant interest.

Saliva

Although some salivary trace elements of centenarians were analyzed by Qui et al. [13], important salivary characteristics such as flow rate, pH, and buffering capacity were not investigated. Moreover, no comparison with other age groups was done. However, there is evidence of an age-related decline in saliva output, resulting in a reduction in unstimulated and stimulated salivary flow rates, antimicrobial proteins (histatin and mucin), and electrolytes (Na, K, Cl, and Ca) [22]. This age-related reduction in salivary flow rates appears to be more pronounced in women than in men [22,23]. As people age, they are more susceptible to acute and chronic diseases,

and the number of medications they take also increases. Regarding this increase in medications, several studies revealed that hyposalivation, xerostomia, and reduced salivary parameters are more likely in patients with an intake of four or more medications and when using combinations of different types of agents [5,22-24]. In contrast, unmedicated older adults display stable salivary flow rates [1]. Considering that demographic changes signify longer lifespans (and thus more acute and chronic diseases) and oral prevention allows the long-term preservation of sound tooth structure, it becomes apparent that the reduction in salivary parameters must be directly linked to oral diseases such as root caries. Centenarians are known to have excellent health for most of their lives, although there appears to be a distinct compression of morbidity [25,26] towards the end of their lifespan and a gender imbalance. Centenarians are most likely to suffer from sensory impairment, mobility issues, musculoskeletal diseases, and arthritis [27]. Centenarians take an average of five medications; consequently, it might be assumed that they have impaired salivary parameters and thereby an increased risk for oral diseases such as root caries. A recent study by Ekstrand et al. that focused on an elderly population with a mean age of 73 years (range, 65-89 years) demonstrated that the use of a highly concentrated fluoride toothpaste (5,000 ppm F-) yields higher salivary fluoride levels. The authors assumed these levels to be sufficiently high to prevent the progression of root caries [28]. Further studies focusing on specialized oral preventive concepts in the elderly and centenarians must provide a set of approaches for both caregivers and elderly, homebound individuals.

Oral microbiome

No studies focusing on the oral microbiome of a centenarian population were found. To investigate the subgingival biofilm of the oral microbiome, supragingival biofilm or saliva can be used. The human oral microbiome has recently been analyzed using sequencing platforms employing 16S ribosomal RNA-based taxonomic surveys. To date, only one study has investigated the periodontal microbiota (40 bacterial species) of the aging mouth [29]. This study included 1,330 subjects in a cross-sectional and partly longitudinal approach. Feres et al. showed that periodontal microbiota in younger adults is similar to that of older adults and remains stable as individuals age [29]. However, the highest mean age of participants in the different age groups was 69.6 ± 4.2 years, and the main focus was periodontal bacterial species [29]. No studies were found that emphasized age-related variations in the human oral microbiome. However, information might be drawn from the NIH Human Microbiome Project and associated research. Although it is still unclear if dynamic changes in the gut microbiome affect the oral microbiome, recent studies have shown a consistency between gut and oral microbiomes, suggesting an overlap in abundance and function at different sites of the body [30]. Due to its impact on human metabolism and immunology, the gut microbiome is proposed as a possible determinant of healthy aging, with a particular health-related composition [31,32]. A cross-sectional investigation by Biagi et al. with 24 semi-supercenarians (≥ 105 years, mean age 106 years), 15 centenarians with a mean age of 100.4 years, 15 younger elderly with a mean age of 72.4 years, and 15 young adults with a mean age of 30.3 years reconstructed the longest trajectory of the gut microbiome to date. The authors observed

that the core microbiome reduces as a person ages. This was accompanied by an increase in subdominant species as well as health-associated taxa that might support extreme longevity [32]. Although smaller in number than at younger age, the core microbiota of frequently occurring symbiotic bacterial groups remain constant during aging, with extremely elderly individuals showing enrichment in health-associated bacteria [32]. During aging, several changes relevant to the oral microbiome are likely to occur. First, individuals' fine motor skills deteriorate, which affects their ability to maintain sufficient oral health care and remove plaque. Second, the increased likelihood of oral diseases and tooth loss leads to a change in dietary habits, i.e., decreased consumption of fiber-rich and chewy foods [33].

Future research should focus on the relationship between aging and the oral microbiome of centenarians and supercentenarians to provide fundamental knowledge regarding oral aging as an adaptive process that continuously re-establishes the mutual interaction between the microbiome and the host.

The current literature is insufficient to draw a definite conclusion regarding the effect of aging on the oral health status of centenarians and supercentenarians. Given the available literature, it can only be speculated that longevity might be associated with better oral conditions compared with other individuals of respective birth cohorts. Due to demographic changes, the number of centenarians is set to increase at a faster rate than that of other age groups. Therefore, further investigations are necessary to determine the underlying mechanisms that may promote or impede oral health and longevity, thus enabling evidence-based treatment approaches for this specific field of dentistry. Future dental care must meet the demographic requirements and ensure that the elderly population is free from oral pain and discomfort. Current diseases related to old age must be treated, and future diseases must be avoided by establishing an elaborate catalogue of preventive measures for both caregivers and elderly patients. Based on this review, it is recommended to investigate the relationship between oral health and longevity, specifically dental status, mucosal and periodontal status, salivary parameters, prosthetic status, the oral microbiome, and oral health-related quality of life.

Conflict of interest

The authors indicate that there is no financial or non-financial conflict of interest.

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