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How to Intervene in the Caries Process in Older Adults: A Joint ORCA and EFCD Expert Delphi Consensus Statement

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Abstract
Aim: To provide recommendations for dental clinicians for the management of dental caries in older adults with special emphasis on root caries lesions. ***Methods:*** A consensus workshop followed by a Delphi consensus process were conducted with an expert panel nominated by ORCA, EFCD, and DGZ boards. Based on a systematic review of the literature, as well as non-systematic literature search, recommendations for clinicians were developed and consented in a two-stage Delphi process. ***Results:*** Demographic and epidemiologic changes will significantly increase the need of management of older adults and root caries in the future. Ageing is associated with a decline of intrinsic capacities and an increased risk of general diseases. As oral and systemic health are linked, bidirectional consequences of diseases and interventions need to be considered. Caries prevention and treatment in older adults must respond to the patient's individual abilities for self-care and cooperation and often involves the support of caregivers. Systemic interventions may involve dietary counselling, oral hygiene instruction, the use of fluoridated toothpastes, and the stimulation of salivary flow. Local interventions to manage root lesions may comprise local biofilm control, application of highly fluoridated toothpastes or varnishes as well as antimicrobial agents. Restorative treatment is often compromised by the accessibility of such root caries lesions as well as the ability of the senior patient to cooperate. If optimum restorative treatment is impossible or inappropriate, long-term stabilization, e.g., by using glass-ionomer cements, and palliative treatments that aim to maintain oral function as long and as well as possible may be the treatment of choice for the individual.

Background

Over the past decades in many countries, improved health care, increased life expectancy but also reduced birth rates, have resulted in significant shifts in population demographics. The proportion of older adults within the population has increased significantly and will increase further in the future [Thomson, 2014; WHO, 2017]. While this trend was first observed in high-income countries, it is now more evident in low- to middle-income countries [WHO, 2017]. This demographic shift in population structure is accompanied by epidemiological changes affecting general and oral healthcare delivery.

While the burden of dental caries has declined over past decades in children and younger adults in many industrialized countries, it is considered a significant and increasing problem in older adults. Today, due to the success of various preventive measures, as well as less invasive restorative interventions, more and more people retain their own teeth throughout their entire life. While tooth loss and removable prosthodontic rehabilitation dominated in older adults some decades ago, today preventive, restorative as well as periodontal treatments have become increasingly important. As welcome as this trend may be for the quality of life of the individual, it is accompanied by problems when individuals become frail and dependent. Prevention of dental diseases and treatment of the natural dentition in the older adult is more complex, time-consuming, and expensive, compared to the oral care for edentate patients.

Ageing is a physiological process and associated with a decline of intrinsic capacity due to impairments of mobility, hearing, tasting, sight as well as performing routine daily or social activities [WHO, 2017]. Frailty is one of the most problematic expressions of ageing [Clegg et al., 2013]. It is defined as a state characterised by reduced physiological reserve and higher vulnerability to stressors which lead to adverse health outcomes including dependency, functional impairment, cognitive decline, and death [Clegg et al., 2013; Hakeem et al., 2019]. Frequent presentations of frailty are fatigue, unexplained weight loss, frequent infections, falls, delirium, and fluctuating disability [Clegg et al., 2013].

The group of "older adults" which are discussed in this paper is heterogenous, ranging from healthy "best agers" to frail, dependent, and multimorbid individuals. Therefore, it is not possible to describe in general the challenges arising in the treatment of caries in older adults. However, some characteristics are seen more frequently in older adults. Many age-related changes directly or indirectly affect risk factors of oral disease. The impairment of mobility and manual dexterity as well as decreased visual acuity impact the execution of adequate oral hygiene in older adults. This, in particular, is problematic as, due to the increased occurrence of gingival recession and existing large restorations, appropriate cleaning of the dentition is significantly more difficult compared to younger patients with a healthier dentition. Cognitive functions decline with increasing age and dementia is significantly more frequent in older adults. With increasing age, the

ability to taste decreases. This as well as a decreased chewing ability may result in reduced consumption of fruits and vegetables and an increased consumption of easily chewable, but potentially cariogenic carbohydrates [Zhu and Hollis, 2014]. Hyposalivation is common in older adults, caused by age-related involution of salivary glands, but often aggravated by insufficient water intake and unwanted side effects of poly-pharmacy.

Besides physiological changes, the risk of developing chronic diseases such as respiratory disorders, diabetes, heart disease, and dementia increases significantly with age [WHO, 2017]. Many of these general diseases are directly linked with oral diseases. Diabetes, for example, is associated with periodontal inflammation and gingival attachment loss. The ingestion of numerous drugs reducing salivation as a side effect can provoke progression of dental caries. Many general diseases or conditions of older adults, however, are indirectly associated with oral diseases. Oral health, for example, is poor in many older patients simply because other diseases become more important compared to dental problems and therefore maintaining oral health is not prioritized. Also, many factors may combine to adversely affect the patient's ability to visit the oral health care team in their office.

As described above, ageing and associated diseases affect oral health in many ways. But vice versa, poor oral health is also associated with general conditions and frailty via several physiological and psychological pathways. Poor oral hygiene, for example is frequent in older patients and it is associated not only with oral diseases including caries and periodontitis but also with general diseases including respiratory infections [Azarpazhooh and Leake, 2006]. There is increasing evidence that mastication can influence cognitive and systemic health [Miquel et al., 2018] and tooth loss and edentulism have not only nutritional but also social consequences [Thomson et al., 2002] and are associated with a higher risk of dementia [Yoo et al., 2019]. Furthermore, oral health has an impact on social interactions and self-esteem [Hakeem et al., 2019].

Due to the increasing number of oral diseases and risks in older adults and the limited prognosis for cure due to general health problems and declining motivation for oral hygiene (as illustrated above), dental care planning for the older adult should be carried out within the perspectives of accepting the chronic nature of the diseases and the potential inability to stabilize oral health conditions in the long term. As a result, appropriate care for this group of patients may include tooth-preserving restorations on teeth that may have a medium- to long-term poor prognosis but are important for function. Also, when older patients still have an acceptable level of oral health, lifecycle-oriented care planning is important as conditions may change in the future. In that perspective, more simple treatments carry less risk compared to extensive care plans involving indirect restorations, especially when considering their maintenance.

Carious lesions usually develop in so-called predilection sites or plaque stagnation areas, such as pits, fissures, and interdental spaces, where the dental biofilm can develop relatively undisturbed. This holds true for root caries lesions as well, as exposed root surfaces, especially in interproximal spaces, are difficult to clean. However, root lesions differ from other predilections sites, as here the lesion process starts in dentin or dental cementum, which is considerably more susceptible to demineralisation compared to enamel. Root surfaces become exposed by physiological recession of the gingival tissues and also as the result of periodontitis and periodontal therapy, which are highly prevalent in older adults. "Freshly" exposed dentine, e.g., after scaling and root planning, is not "matured" by fluoride uptake and thus is more susceptible to the caries process. Therefore, risk groups comprise older adults with exposed root surfaces and caries activity factors including hyposalivation, radiation, and extensive periodontal treatment. The local risk of development and progression of root caries as well as the prognosis of these lesions differ between freely accessible surfaces and those surfaces that are difficult to access for cleaning as well as restorative procedures.

Materials and Methods

On the occasion of the 9th ConsEuro Congress in Berlin in June 2019, the European Federation of Conservative Dentistry (EFCD), the European Organization for Caries Research (ORCA), and the German Association of Operative Dentistry (DGZ) conducted a joined Delphi workshop to address the question of "How to intervene in the caries process." One year before, ORCA and EFCD had conducted a Delphi consensus of "When to intervene in the caries process" [Schwendicke et al., 2019]. Due to the high complexity of the question of how to treat dental caries, the topic was divided into three age groups of patients: 1. children and adolescents, 2. adults, and 3. older adults. In the current consensus statement, the results regarding the age group of older adults will be addressed.

The workshop participants had been selected and invited by the boards of ORCA, EFCD, and DGZ aiming at a well-balanced representation of experts in the fields of cariology, restorative dentistry, paediatric dentistry, and gerodontology. While the majority of the consensus committee attended the workshop in Berlin, some members (P.B., G.C., K.E., H.J., H.T., A.Z., and D.Z.) were not able to attend the conference but contributed equally as the Berlin at-

tendees in the development and Delphi process as well as manuscript writing. The costs of the workshop were covered solely by the three participating associations.

To summarize the current scientific knowledge, selected members of the three associations were asked prior to the meeting to prepare systematic literature reviews regarding the treatment of most prevalent caries forms in the three age groups. The reviews were published in *Caries Research* and *Clinical Oral Investigations* [Meyer-Lueckel et al., 2019; Askar et al., 2020; Santamaria et al., 2020, in press; Schmoeckel et al., 2020; Splieth et al., 2020]. In preparation of the current consensus, a systematic review on the management of root caries was performed [Meyer-Lueckel et al., 2019]. Based on this systematic review as well as other literature, structured consensus statements, i.e., recommendations, were drafted by the group chairs (S.P., N.O.) and sent to the delegates prior to the meeting. At the meeting, each statement was discussed extensively and modified until consensus was reached. The strength of each recommendation was evaluated by the group in the levels "strong," "moderate," or "weak", based on the scientific evidence supporting the statement. Recommendations supported by unequivocal evidence (e.g., several randomized controlled trials) were evaluated as "strong." Recommendations based on moderate evidence (e.g., high-quality clinical studies such as randomized controlled trials with similar results) were evaluated as "moderate." Finally, recommendations based on expert opinion only and supported by weak evidence (e.g., no clinical studies or only low-quality studies or studies with contradicting results) were ranked as "weak."

The online voting on the statements was graded from 1 (completely disagree) to 10 (completely agree) and performed using an online platform (Surveyjet, Calibrum, St. George, UT, USA). All committee members voted on all statements/recommendations. At least 70% of the votes over 7 were considered as acceptance of the statement by the group, and in addition the median of all votes was calculated for each recommendation. An additional field for free-text comments was also available to illustrate the reasoning for a certain decision or proposals for future modifications. All but one statements (see below) were accepted in the Delphi process.

Results

Caries Management in Older Adults

The heterogeneity of the age group of older adults has been discussed above. Due to the extremely varying abilities and general health status of older adults, individual caries management has to address the specific patient's/individual's characteristics and needs. In adults, these factors play only minor roles in treatment decision-making as adults usually have a relatively high capacity to tolerate treatment time, effort, and stress. The treatment of self-dependent older adults often does not differ significantly from younger adults, although a lifecycle-oriented approach accompanied with shared decision-making may result in different management for the healthy older adult. However, with aging, our elderly patients become more and more dependent and frail, leading to individual impairments to be considered in care planning and need to adjust treatment aims to be practical and pragmatic. Caries management in younger adult patients should follow a curative approach and aim at long-lasting restorations and optimum aesthetic and functional results. In frail elderly patients, however, quite often palliative strategies are to be preferred and aesthetic outcomes may be less of a priority.

Due to the quite similar needs of children and older adults, in gerodontology often similar strategies to those in paediatric dentistry can be followed. Both age groups may depend on the support for oral hygiene, tend to have a more cariogenic diet, and cannot cope with long and exhausting treatment sessions, for example. Therefore, in both groups, caregivers may need to be involved to support treatment in dental practice and maintenance of a healthy diet and oral hygiene at home. As in younger patients, natural exfoliation justifies temporary solutions, in dependent and frail elderly, the limited life expectations as well as prioritization of the patient's needs might also often justify more pragmatic approaches.

The question of "how to maintain oral function as long as possible with a reasonable and (for the older adult) tolerable effort" is often the basis of treatment decision-making. In many multi-factorial situations (dry mouth, medication, reduced physical skills) a restorative approach is rather unrealistic. Here, palliative treatments and simpler, tooth life-prolonging restorative strategies are justified. If it is unrealistic to control the caries process by non-invasive and restorative measures, especially in the molar region, reduced dental arch-length concepts may be indicated and individually accepted.

Recommendations

- The age group of older adults is heterogenous with regard to many aspects affecting dental disease prevention and treatment, such as the patient's ability to perform oral hygiene, to visit the dental clinic, to cooperate as well as their general condition and life expectancy. Individual needs and abilities should be reflected in prevention and care planning. Strength of recommendation: weak; agreement: 92%; median: 10
- As this age group is prone to more rapid changes in systemic and related oral conditions, monitoring frequency should be adapted to the individual. Strength of recommendation: weak; agreement: 100%; median: 10
- In older adults, root caries is the dominant primary caries form. This should be considered in prevention

and diagnosis. Strength of recommendation: moderate; agreement: 100%; median: 10
- In dependent older adults, stabilisation or palliative treatments and tooth life-prolonging restorations may be preferred as opposed to standard protocol treatments that are routinely used in healthy and fit adult patients. The main goal is to preserve adequate oral function in a lifecycle-oriented approach. In severely dependent patients (e.g., progressive dementia, planned long-term hospitalization or institutionalisation) extensive restorative treatment may not be possible/indicated. In these cases extraction may be considered. Strength of recommendation: weak; agreement: 92%; median: 10
- Systemic and oral health are linked. Good quality oral hygiene can contribute to the prevention and control of general diseases like pneumonia and diabetes. Strength of recommendation: moderate; agreement: 96%; median: 10

Prevention and Treatment on the Patient Level

The aetiology of dental caries implicates that caries management should not only aim to "heal" local signs and symptoms of the disease (i.e., caries lesions) by restoration of diseased oral tissues; rather, caries management should address the aetiological factors of caries which often affect the entire oral cavity and even the patient in general.

Recommendations
- A reduced frequency of sugar intake should be recommended. Strength of recommendation: weak; agreement: 100%; median: 10
- Patients should be advised to brush their teeth at least twice daily with fluoride toothpaste (≥1,500 ppm fluoride). Strength of recommendation: strong; agreement: 96%; median: 10
- As most older adults have enlarged interdental spaces that cannot be cleaned sufficiently with toothbrushing alone, the use of interdental brushes, preferably with a fluoridated toothpaste, should be recommended and trained regularly. Strength of recommendation: weak; agreement: 96%; median: 10
- As manual dexterity usually decreases in older adults, supportive oral hygiene devices such as powered toothbrushes might be considered. Strength of recommendation: weak; agreement: 96%; median: 10
- If the patient is unable to perform sufficiently effective oral hygiene, caregivers should be advised to provide daily oral hygiene. Strength of recommendation: weak; agreement: 100%; median: 10

Root Caries Management

Similar to enamel caries, root caries is a dynamic process with active and inactive disease stages. Active lesions undergo progressive mineral loss and thus require therapeutic intervention. Inactive lesions, in contrast, do not undergo current mineral loss and may even gain mineral. Therefore, inactive lesions can be regarded as scars and do not need therapeutic intervention. The support of natural "healing" of root lesions by addressing the aetiological factors of the caries process should be the management of choice. The natural healing or remineralisation process can be promoted by non-invasive strategies like use of fluoride products, salivary stimulation, improvement of oral hygiene to disrupt the dysbiotic biofilm, or dietary interventions. However, if aetiological factors cannot be controlled, cavitated root caries lesions will require restorative treatment.

Recommendations
- Root caries lesions that are inactive (hard, shiny surface, plaque-free [Nyvad et al., 1999]) should be regarded as scars and do not need additional treatment. However, they should be monitored. Strength of recommendation: moderate; agreement: 96%; median: 10
- Active root lesions (soft surface, plaque-covered [Nyvad et al., 1999]) should be treated according to their location and depth (see below). If lesion arrest can be achieved by non-invasive interventions, they should be preferred compared to restorative interventions. Strength of recommendation: moderate; agreement: 100%; median: 10

Non-Invasive Interventions

Non-invasive interventions to treat root caries lesions target the aetiological factors affecting the caries process such as diet, the biofilm, or the mineralization process. Therefore, many non-invasive interventions affect the patient or the entire oral cavity (see recommendations above). Individual lesions can additionally be treated with local interventions.

Recommendations
- Accessible lesions should be brushed daily by the patient (alone or supported by caregivers). The patient and/or caregivers should be instructed to perform cleaning of carious surfaces or those at risk. Strength of recommendation: moderate; agreement: 88%; median: 10
- In older adults with increased (root) caries susceptibility and/or active root lesions, high-concentration fluo-

ride dentifrice (5,000 ppm) should be preferred over regular toothpaste. Strength of recommendation: moderate; agreement: 88%; median: 10
- In older adults with increased (root) caries susceptibility and/or active root lesions, highly concentrated fluoride varnish (>20,000 ppm) can be applied. Strength of recommendation: weak; agreement: 88%; median: 10
- Active root caries lesions can be treated with silver (diamine) fluoride (SF >30%). Strength of recommendation: weak; agreement: 80%; median: 10

The following recommendation was discussed in the consensus meeting but later rejected due to missing acceptance in the Delphi:
- In older adults with increased (root) caries susceptibility and/or active root lesions, chlorhexidine (≥1%) varnish can be applied. Strength of recommendation: weak; agreement: 48%; median: 7

Micro-Invasive Interventions

Micro-invasive interventions such as sealing methods are widely used to prevent and manage enamel caries lesions. Due to lack of scientific evidence regarding their application on root caries or dentine, no recommendation can be made.

Invasive Interventions

Invasive interventions to manage root caries lesions comprise at least partial removal of diseased tissue and restoration of the resultant defect by alloplastic materials such as resins, metals, or cements. As these measures usually aim at the alleviation of the symptoms of the caries process (i.e., caries lesions), they are not curative by nature and should be accompanied with non-invasive interventions to treat the underlying disease process (see above). Restorative treatments for root lesions may have poorer prognosis compared to coronal restorations, especially in high-risk/multi-factorial situations. Therefore, the assumption that a restoration improves oral health quality is not automatically valid and should be critically evaluated in those cases.

Recommendations
- Active root lesions that cannot be arrested by non-invasive measures should be treated restoratively. Strength of recommendation: moderate; agreement: 92%; median: 10
- For the restoration of root lesions, both resin composites as well as resin-modified or conventional glass-ionomer cements can be used, depending on aesthetics and available possibilities for moisture control. Strength of recommendation: moderate; agreement: 96%; median: 10
- Glass-ionomer cements may be preferable if handling and moisture control are compromised. Strength of recommendation: weak; agreement: 84%; median: 10
- Atraumatic restorative technique may result in higher failure rates than conventional restorative techniques but can be applied in cases of difficult access and dependent patients. Strength of recommendation: moderate; agreement: 88%; median: 10

Conclusions

More than any other age group, the oral health management of older adults requires extensive medical and pharmacological knowledge as well as interdisciplinary consultation. In older adults, individual physical and mental abilities as well as requirements and expectations need to be considered carefully in care planning, when compared to younger adult patients. Even though the aetiology of dental caries is similar in all age groups, pathogenic factors and patients' abilities may be differently weighted in older adults. Therefore, preventive and treatment strategies and concepts that are well established for children and adults need to be adapted to this senior age group.

Compared to the treatment of children and adults with coronal caries, the scientific evidence for the treatment of dental caries in older adults and on root surfaces is relatively scarce. Thus, many of the consensus recommendations are based on weak evidence. Especially, in light of the described demographic and epidemiologic changes and the resulting future treatment need, there is a need for further research in this field.

Statement of Ethics

No ethical concern arose for this systematic review.

Conflict of Interest Statement

A.B. received support for a researcher-led SR of sugar-free gum by Mars Wrigley. P.B. received an honorarium for consultancy on product development regarding future caries treatments in medically compromised adults from Mayser Pharma. L.B. received for support for research protocols regarding dental adhesives from 3M ESPE, Ivoclar Vivadent, Dentsply Sirona, VOCO, Heraeus Kulzer, Kuraray Noritake, Ultradent, Pulpdent and material sam-

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Author Contributions

S.P. and N.O. prepared the manuscript based on the systematic review and drafted the statements to be discussed and voted on by all the authors. All other authors corrected and approved the manuscript. All authors participated in the Delphi process. For this type of study, formal consent is not required.

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