

# Management of Caries in Older Adults



Gerry McKenna, Martina Hayes, and Cristiane DaMata

## 1 Global Epidemiology

Globally we are seeing the effects of an aging population. In many high income countries, as birth rates fall and life expectancy increases, the proportion of older adults within the general population has increased significantly. As fertility rates move towards lower levels, mortality decline, especially at older ages, assumes an increasingly important role in population aging. In low and middle income countries, where low fertility has prevailed for a significant period of time, relative increases in the older population are now primarily determined by improved chances of surviving to old age [1]. Over the next 50 years, life expectancy at birth is projected to increase globally by 10 years, to reach 76 years in 2045–2050. By the end of the next quarter century, life expectancy at birth is expected to reach, on average, 80 years in the more economically developed regions and 71 years in the less economically developed regions. As a result of the generalized shift in the age distribution of mortality towards older groups, more people will survive into their seventh, eighth and ninth decades around the world [2].

---

G. McKenna (✉)

Centre for Public Health, Queen's University Belfast, Belfast, Northern Ireland, UK

e-mail: [G.McKenna@qub.ac.uk](mailto:G.McKenna@qub.ac.uk)

M. Hayes · C. DaMata

Cork University Dental School and Hospital, University College Cork, Cork, Ireland

© The Author(s), under exclusive license to Springer Nature  
Switzerland AG 2022

C.-M. Hogue, J. G. Ruiz (eds.), *Oral Health and Aging*,  
[https://doi.org/10.1007/978-3-030-85993-0\\_7](https://doi.org/10.1007/978-3-030-85993-0_7)

## 2 The Oral Health of Older Adults

Epidemiological dental surveys from around the world clearly indicate that tooth retention has increased significantly amongst older adults as they retain their natural teeth into old age [3]. Unfortunately, the cumulative nature of the two main destructive dental diseases: caries and periodontitis, dictate that aging is always likely to be a factor associated with total tooth loss particularly amongst patients in lower socio-economic groups [4]. Clear socio-economic gradients in complete tooth loss have been identified in many countries, including the United Kingdom, Japan, Korea and in Scandinavia [3, 5–7].

Although the overall prevalence of total tooth loss has fallen sharply over recent decades, many patients now become edentate at an older age when they are generally less able to adapt to the limitations of complete dentures. The attitudes of older patients to oral health also appear to have changed as many take advantage of widely available sources of information and demand more from the dental profession. As a result, increasing numbers expect conservative treatment approaches rather than those previously centered around extractions and subsequent replacement of natural teeth [8].

While increasing tooth retention is seen as a leap forward in the oral health of the older population, it also brings with it the challenges of managing chronic dental diseases, including caries and periodontal disease. Due to factors, such as diet, reduced manual dexterity and xerostomia, these chronic diseases can cause considerable pain and suffering amongst older patients and impair oral function [9]. Dental caries remains a problem for this age group with a high prevalence of coronal and root surface caries found amongst old-age populations [10, 11]. In the 1998 UK Adult Dental Health Survey, the proportion of adults with 18 or more sound and unrestored teeth was only 5% amongst those aged 55 years and over [12]. The 2009 UK Adult Dental Health Survey indicated that this figure had improved but still remained at only 13% [12, 13]. The 2009 UK Adult Dental Health Survey reported that 27% of adults aged 65–74 years had evidence of dental caries whilst this figure increased to 40% for those aged 75–84 years [13].

The 1998 UK Dental Health Survey showed that almost 25% of the older adults had 12 or more teeth with a root surface that was either exposed, worn, filled or decayed [12]. The 2009 Survey reported that 73% of all adults had exposed root surfaces, and this increased to 90% for those aged over 55 years. The same survey reported that 11% of 55–64 years old had active root caries compared with 20% of those aged 75–84 years [13].

## 3 Oral Health in Long-Term Care Facilities (LTCFS)

It is widely reported that the oral health status of older adults within LTCFs is significantly worse than their community living peers [14]. With increasing age, the ability to care for their mouth deteriorates: polypharmacy leads to xerostomia, and

diets can become rich in sugars, while good daily oral hygiene is essential for the maintenance of complex dental restorations. All these factors increase the risk of oral disease and directly impact comorbidities.

Unfortunately, a growing proportion of residents in LTCFs are unable to self-care, and with increasing dependency, oral hygiene practices present a significant challenge. Current prevention practices and service provision in LTCFs is often poor. Challenges include inadequate resources and training, and these are compounded by high staff turnover. There is a significant difficulty in obtaining routine dental care due to the very complex needs of institutionalized older people, with a significant proportion suffering from cognitive impairment and dementia. Access to domiciliary dental services is often limited with subsequent admission to hospitals for dental problems which can be distressing for individuals and their families and very costly to the healthcare provider [2].

Within the United Kingdom, the National Institute for Health and Care Excellence (NICE) publishes evidence-based guidelines on all aspects of healthcare. In 2016, NICE published ‘Oral health for adults in care homes (NG48)’ which included a series of recommendations for LTCFs, including improving access to dental services for LTCF residents, improving the oral health knowledge and skills of care home staff and the implementation of oral health assessments, mouth care plans and daily oral care for all residents [15]. However, adoption of these recommendations has been challenging in many LTCFs as demonstrated by follow-up surveys in the United Kingdom [16]. For a more in-depth discussion on the topic of long-term care, please refer to chapter “[Oral Care in Long-Term Care Settings](#)”.

## 4 Dental Caries

Dental caries is a multifactorial, bacterially mediated process that results in the destruction of mineralized tooth tissues. In light of the emergence of the partially dentate older population, there is a need for clinicians to understand the caries disease process in order to establish effective preventive and management regimes. However, older patients can present with some unique etiological considerations which increase their risk of developing dental caries particularly on the root surface [17]. Root caries as ‘a cavitation below the cement-enamel junction (CEJ), not usually including the adjacent enamel, usually discoloured, softened, ill-defined and involving both cementum and underlying dentine’ [18]. The root surface may be particularly vulnerable to mechanical destruction compared to enamel due to differences in the structure and chemical composition of cementum and dentine. In a population who are frequently exposed to scaling by dental health professionals, the cementum layer is frequently abraded away, exposing the dentine (Fig. 1). Root cementum and dentine are structurally different from enamel and react differently to cariogenic challenges – of note the critical pH of dentine and cementum is approximately 6.4 while that of enamel is 5.5.

**Fig. 1** Exposed root surfaces in a partially dentate older patient



**Fig. 2** Root caries in a partially dentate older patient



**Fig. 3** Root caries in the abutment teeth for a removable partial denture



## 5 Diagnosing Root Surface Caries

The most common clinical descriptors of root caries are visual-tactile changes in the root surface (Figs. 2 and 3). Colour can range from tan to brown to black, and while color change is indicative of root caries, no correlation has been shown between color and lesion activity. Texture appears to be a better indicator of lesion activity, with active lesions being less resistant to gently probing than quiescent or

arrested lesions [19]. Many root caries lesions develop on the proximal surfaces and up to 20% can occur subgingivally [20]. These areas are challenging for the clinician to visualize and to access with a probe. As a result, lesions are often not detected at an early stage. The lesions tend to spread in a wide, circumferential pattern and pain is not a feature until an advanced stage. Frustrating for the dentist and the patient, the first sign of root caries may be a catastrophic fracture of the tooth at the gingival level. The difficulties of detecting this disease in its early stages is a considerable challenge.

## 6 Risk Assessment

A caries risk assessment should be a part of information gathered in treatment planning for all patients. Given the challenges in detecting root carious lesions early, particular efforts should focus on identifying those older adults at high risk of developing root caries and implement appropriate risk reduction measures. Root caries is a preventable disease; however, access to care, adherence issues, and cost may preclude the use of a preventive intervention on the entire older adult population. This means that one-third of the older adult population bears much of the root caries burden [21]. Therefore, if these individuals could be identified prior to developing the disease, targeted prevention measures could be delivered. A systematic review of root caries risk indicators found that the best predictor of future root caries development was a history of past root caries disease [22]. The clinician should treat any individual with a filled or decayed root surface as a high-risk individual for future disease. Other risk factors which have been identified include older age, number of teeth present, poor plaque control, and wearing removable partial dentures [23].

## 7 Caries Prevention Strategies for Older Adults

### 7.1 Oral Hygiene Advice for Older Adults

Beyond the oral cavity, many older people also carry the burden of systemic medical conditions [24]. These can diminish the priority for optimal oral hygiene in the daily routine of some older patients, while others will be dependent on caregivers for mechanical cleaning of the teeth. Many older adults are prescribed a large number of daily medications (polypharmacy), and xerostomia is a side effect of many commonly prescribed drugs [25]. Dry mouth is a major risk factor for dental caries as the protective lubrication of saliva has been removed. For a more in-depth discussion on the topic, please refer to chapter “[Xerostomia and Hyposalivation](#)”. Loss of manual dexterity, secondary to arthritis or neuromuscular degeneration, presents many older patients with an additional obstacle in maintaining adequate plaque

control. Something as simple as holding a toothbrush can be difficult, and manipulation of dental floss or other intricate interdental cleaning aids becomes impossible. Diminishing eyesight can also hinder proper oral hygiene technique. Some patients may be embarrassed to admit to any decline in physical capabilities, and oral health can suffer significantly before appropriate assistance is provided by a caregiver. Dentists and dental hygienists should consider this possibility if they observe a decline in oral hygiene in an older patient and highlight aids such as toothbrush grips, electric toothbrushes and holders for interdental floss and mouthwashes [26].

The simplest home-based measure to reduce caries risk is to incorporate a high-fluoride mouthwash into the daily routine. These are easy to use and do not require a high level of manual dexterity. Alcohol-free mouthwashes are more suitable for patients with dry mouth, and there are a number of mouthwashes specifically formulated to ease the symptoms of xerostomia. Patients should be advised to avoid using carbonated drinks or acidic sweets to alleviate their dry mouth; instead, providers should direct them to an alternative such as sugar-free chewing gum. While many older patients will be aware of the role of sugar in dental disease, the dangers of acid erosion may be less well known amongst this group.

## **7.2 Fluoride Interventions**

High-fluoride mouthwashes can provide an additional source of fluoride, and daily use of 0.2% sodium fluoride mouthwash is frequently recommended for patients judged to be at high risk of developing caries. It may be preferable to ask patients to use the mouthwash at a different time to tooth brushing. This will allow spacing of fluoride exposure throughout the day to maximize its benefit; after lunch or dinner may be suggested as a suitable time to flush out any food debris. High-fluoride toothpaste may also be a useful preventive tool for older patients at high risk of developing caries. A meta-analysis of six randomized controlled trials demonstrated that 2800 ppm fluoride toothpaste resulted in significantly lower caries incidence compared to a 1100 ppm fluoride control [27]. As patients are well used to using toothpaste, a change to a high-fluoride toothpaste should be easily tolerated and 5000 ppm formulations are also available. High-strength-fluoride toothpastes should be kept out of reach of young children, and patients should be encouraged to expectorate after brushing, particularly where assisted toothbrushing is facilitated by a caregiver [28].

## **7.3 Chlorhexidine Interventions**

Older adults often experience more rapid plaque accumulation than younger adults due to the dual effects of gingival recession and reduced salivary function. A number of studies have demonstrated the effectiveness of chlorhexidine 0.12% mouthwash in LTCFs Term Care Facilities to aid oral hygiene and, despite the potential for

staining, is a very useful adjunct in older adults who have difficulty in maintaining adequate plaque control through brushing alone. Chlorhexidine works best on a plaque-free surfaces to prevent plaque reforming, but it can also be effective in the presence of plaque [29]. Chlorhexidine mouthwash should be used at a different time to toothbrushing as many brands of toothpaste contain sodium laurel sulphate – a detergent which inactivates chlorhexidine.

#### **7.4 *CPP-ACP Intervention***

A topical paste containing bioavailable calcium and phosphate has been commercially developed as Recaldent™, which is sold as Tooth Mousse® or as MI Paste Plus® (in combination with 900 ppm fluoride) (GC Corporation, Japan). As it is derived from milk casein, all potential users of Recaldent™ products should be questioned about any possible IgE-mediated casein allergies. These products can be applied at night-time after toothbrushing, and the manufacturers advise application of a pea-sized amount to each arch using a clean dry finger. The paste must be held in the mouth at least 3 minutes, as the longer it is maintained in the mouth with saliva, the more effective it is. After spitting out, patients are advised not to eat or drink for 30 minutes, and rinsing is to be avoided.

#### **7.5 *Professionally Administered Interventions***

For older patients with a high caries rate or poor adherence with oral hygiene instruction, there are a number of surgery-based interventions available to reduce caries risk. The incorporation of chlorhexidine, fluoride and silver diamine fluoride (SDF) varnishes in the control of dental caries in older patients is a relatively recent development. A protective non-invasive medicament for preventing root caries lesions is of particular interest due to the nature of this destructive dental disease. A recently published systematic review and meta-analysis concluded that SDF provided a protective impact on root caries lesions after 24 months [30]. The application of varnishes is simple, quick and non-invasive and can be used in a domiciliary setting to reduce the development of new caries lesions [31]. Furthermore, it reduces dependence on patient adherence for success, and treatment can be provided by dental care professionals.

### **8 Challenges in the Operative Management of Root Caries**

Root caries lesions may exhibit mixed cavity margins positioned in enamel as well as dentine [32]. Restoration of this cavity type is challenging with respect to the lack of restorative materials, which bond equally well to both dental tissues. The evidence

base for the selection of restorative material for the restoration of a root surface lesion is neither plentiful nor convincing. Most of the scientific literature examines lesions restored with amalgam, glass ionomer cement (GIC), resin-modified glass ionomer cement (RMGIC), modified polyacid resins (“compomers”) or composite resins. A systematic review published in 2016 concluded that there was insufficient evidence to recommend any specific material [33]. However, failure rates of root caries restorations across all materials were extremely high; 82% of GIC restorations were considered a “failure” after just 24 months. A total of 25% of all composite restorations had developed recurrent caries after 2 years. Despite the poor survival rates of GIC restorations, many authors still conclude that GIC is the material of choice for root caries as conventionally setting glass ionomer cements were associated with protection against secondary caries – even after the filling itself had been lost [34]. Clinical judgement is essential in each individual case, and the choice of restorative material to restore a carious lesion on a root surface is influenced by the location of the lesion, aesthetic requirements of the patient, moisture control and future caries risk.

## **9 Utilizing Atraumatic Restorative Treatment (ART) for Caries Management in Older Adults**

Providing operative dental care to older patients can be challenging, and traditional restorative approaches may not be accessible or even acceptable to some groups. Several authors have pointed out that most economically prosperous countries still prioritize traditional treatment of disease over prevention measures. This is, arguably, excessively costly and does not consider long-term maintenance requirements [35, 36].

In order to avoid further tooth tissue loss and enhance prevention amongst older individuals, minimally invasive dentistry (MID) should always be the first line of treatment for caries. It prioritizes prevention and provides guidance for patients to empower them to be responsible for their own oral health and intervene as conservatively as possible when a surgical approach is judged necessary, thus avoiding unnecessary tooth tissue removal. It was born from the evolution in the understanding of the caries process and the mechanisms involved in its beginning, progression and control, together with improved dental materials. According to the MID concept, early caries detection and caries risk assessment, remineralization of demineralized enamel and dentine and optimal caries-preventive measures should always be used throughout an individual’s life, and operative interventions should only be employed when all of these have failed [37]. In order to decide for a preventive or operative intervention, it is important to differentiate between active and arrested, cavitated and non-cavitated and cleansable and plaque trapping lesions. The type of lesion will influence not only the treatment to be carried out but also the type of material to be used. Cavitated lesions on the root surface that are shallow might become self-cleansable and arrested, and therefore, restoration might not be necessarily recommended. When there is a need for a filling to be placed, cavity preparation should be as minimal as possible to conserve natural tooth tissue.

Atraumatic restorative treatment (ART) is a very effective yet minimally invasive surgical approach for restoration of carious teeth (Fig. 4). It uses hand instruments for



**Fig. 4** Root caries restored using ART on 15, occlusal caries on 47 also restored using ART



accessing carious lesions and removing decomposed dentine and a high-viscosity glass-ionomer to restore the cavity. Many studies worldwide have demonstrated that ART can achieve high survival rates in single-surface permanent teeth [10, 38, 39]. ART can be used successfully in non-clinical settings, including LTCFs and hospitals, and has been shown to be both cost-effective and acceptable to older adults [40, 41]. Furthermore, ART can be carried out by dental care professionals (DCPs), including therapists and hygienists. The use of DCPs to provide oral care for older people may help to improve access to dental services particularly for patients who are resident in LTCFs [42, 43]. The use of the ART approach could thus result in preventive and restorative care being delivered to a larger number of people compared to traditional restorative approaches. Studies carried out in older adults have demonstrated comparable survival rates for both ART and conventional restorations with glass ionomers [44, 45]. One of the largest studies which compared ART with a conventional restorative technique to treat carious lesions on older patients found that only 8.6% of the ART restorations placed on the root surface failed after 5 years. Overall, failure rates were similar between the ART and the conventional group [10]. Furthermore, the same study found that older adults accept ART well and are happy not to receive anaesthesia or drilling for restoration provision. Dental anxiety is a known barrier for dental attendance, and fearful older adults are less likely to visit a dentist and more likely to avoid or delay dental treatment. The use of ART could change this negative perception of dental treatment and make dental attendance more regular for some patients.

## 10 Consideration of Caries Development When Replacing Missing Teeth

Previously in this chapter, we have discussed preventive interventions to prevent older adults developing caries including effective mechanical cleaning and the use of fluoride. However, in addition to effective preventative regimes, operative dental treatment can also become an etiological driver for the development of caries. The most common example of this is in the replacement of missing teeth particularly when using a removable partial denture (RPD) [23, 46]. RPDs, which are

constructed from acrylic resin, typically cover substantial amounts of the soft tissues and create plaque traps and dead spaces where caries can develop (Fig. 5). Acrylic resin RPDs should be used as transitional prostheses where the remaining teeth are of poor prognosis and additions to the RPD are anticipated in the short to medium term. [47] Where the remaining natural dentition is of a good prognosis and a removable prosthesis is planned, then this should be constructed using a cobalt-chromium framework. This RPD design will provide a prosthesis which is tooth-borne but also minimizes the amount of coverage of the remaining hard and soft

**Fig. 5** Lower acrylic resin RPD with extensive coverage of the gingival margins around the remaining natural teeth



**Fig. 6** Upper and lower cobalt-chromium RPDs which have been designed to minimize coverage of the remaining hard and soft tissues



**Fig. 7** A shortened dental arch in a partially dentate older patient



tissues (Fig. 6). Whilst a good preventive regime will still be required, the remaining dentition should be less prone to developing caries.

Where replacement of natural teeth is less extensive, then fixed prosthodontics can be considered, either as tooth supported or implant supported restorations. Where systemic medical comorbidities are well controlled, then dental implants can have excellent success rates in older adults [24]. Consideration should also be given to the use of the shortened dental arch concept, where a functional dentition is achieved through retention of natural teeth or using fixed prosthodontics to restore 10 occluding pairs of contacts (Fig. 7). This treatment planning philosophy does not necessitate the use of a RPD and is therefore easier for the patient to maintain and more cost-effective to deliver [48].

## 11 Conclusions

This chapter has discussed the changing oral health profile of older adults within the population. The emergence of a partially dentate older population is not only a significant advance in terms of oral health but also provides significant challenges for clinicians and patients in managing chronic dental diseases, including caries. Despite root caries being a preventable dental disease, prevalence is very high amongst older adults. Whilst some operative strategies have been discussed, including the application of ART, the most important element is prevention. Interventions using high-fluoride toothpaste and varnish are effective in preventing root caries, and the use of SDF is increasingly promising. Within the context of prevention, clinicians must ensure that they are not adding to the maintenance burden for older patients by providing RPDs, which are plaque retentive and encourage caries development. Alternative approaches should be considered including utilizing the shortened dental arch concept, which provides a functional yet maintainable dentition for older adults.

## References

1. UN Department of Economics and Social Affairs. World Population Prospects – Population Division – United Nations. The International Journal of Logistics Management.
2. McKenna G, Tsakos G, Burke FM, Brocklehurst P. Managing an ageing population: challenging oral epidemiology. *Primary Dental Care*. 2020;9(3):14–7.
3. Steele J, Sullivan IO. Executive summary: adult dental health survey 2009. Health (San Francisco). Published online. 2011.
4. Pearce MS, Thomson WM, Walls AWG, Steele JG. Lifecourse socio-economic mobility and oral health in middle age. *J Dental Res*. Published online. 2009; <https://doi.org/10.1177/0022034509344524>.
5. Jung S-H, Tsakos G, Sheiham A, Jae-In R, Watt RG. Socio-economic status and oral health-related behaviours in Korean adolescents. *Soc Sci Med*. 2010;70(11):1780–8.
6. Aida J, Kondo K, Kondo N, Watt RG, Sheiham A, Tsakos G. Income inequality, social capital and self-rated health and dental status in older Japanese. *Soc Sci Med*. Published online. 2011; <https://doi.org/10.1016/j.socscimed.2011.09.005>.
7. Bernabé E, Watt RG, Sheiham A, et al. Childhood socioeconomic position, adult sense of coherence and tooth retention. *Community Dent Oral Epidemiol*. Published online. 2012; <https://doi.org/10.1111/j.1600-0528.2011.00633.x>.
8. Cronin M, Meaney S, Jepsen NJA, Allen PF. A qualitative study of trends in patient preferences for the management of the partially dentate state. *Gerodontology*. Published online. 2009; <https://doi.org/10.1111/j.1741-2358.2008.00239.x>.
9. Hayes M, Da Mata C, Cole M, McKenna G, Burke F, Allen PF. Risk indicators associated with root caries in independently living older adults. *J Dent*. Published online. 2016; <https://doi.org/10.1016/j.jdent.2016.05.006>.
10. da Mata C, McKenna G, Anweigi L, et al. An RCT of atraumatic restorative treatment for older adults: 5 year results. *J Dent*. 2019;83 <https://doi.org/10.1016/j.jdent.2019.03.003>.
11. Hayes M, Da Mata C, McKenna G, Burke FM, Allen PF. Evaluation of the Cariogram for root caries prediction. *J Dent*. Published online. 2017; <https://doi.org/10.1016/j.jdent.2017.04.010>.
12. Kelly M, Steele J, Nuttall N, Bradnock G, Morris J, Nunn J et al. Adult dental health survey: oral health in the United Kingdom 1998. The information centre for health and social care. Published online. 1998.
13. White DA, Tsakos G, Pitts NB, et al. Adult Dental Health Survey 2009: common oral health conditions and their impact on the population. *Br Dent J*. Published online. 2012; <https://doi.org/10.1038/sj.bdj.2012.1088>.
14. Karki AJ, Monaghan N, Morgan M. Oral health status of older people living in care homes in Wales. *Br Dent J*. 2016;51:8–14.
15. Excellence NI of H and C. Improving Oral Health for Adults in Care Homes; 2016.
16. Care Quality Commission. Smiling Matters; 2019.
17. Hayes M, Blum IR, da Mata C. Contemporary challenges and management of dental caries in the older population. *Primary Dent J*. Published online. 2020; <https://doi.org/10.1177/2050168420943075>.
18. Jordan H, Sumney D. Root surface caries: review of the literature and significance of the problem. *J Periodontol*. 1973;44(3):158–63.
19. Lynch E, Beighton D. A comparison of primary root caries lesions classified according to colour. *Caries Res*. 1994;28(4):233–9.
20. MinQuan D, Han J, BaoJun T, Zhou Y, Wu B, Bian Z. Root caries patterns and risk factors of middle-aged and elderly people in China. *Community Dent Oral Epidemiol*. 2009;27(3):260–6.
21. Griffin S, Griffin PM, Swann J, Zlobin N. Estimating rates of new root caries in older adults. *J Dent Res*. 2004;83(8):634–48.
22. Ritter A, Shugars D, Bader JD. Root caries risk indicators: a systematic review of risk models. *Community Dent Oral Epidemiol*. 2010;38(5):383–97.

23. Hayes M, Da Mata C, Cole M, McKenna G, Burke F, Allen PF. Risk indicators associated with root caries in independently living older adults. *J Dent*. 2016;51 <https://doi.org/10.1016/j.jdent.2016.05.006>.
24. Schimmel M, Srinivasan M, McKenna G, Müller F. Effect of advanced age and/or systemic medical conditions on dental implant survival: a systematic review and meta-analysis. *Clin Oral Implants Res*. 2018;29 <https://doi.org/10.1111/clr.13288>.
25. de Mata C, McKenna G, Burke FM. Caries and the older patient. *Dent Update*. 2011;38(6) <https://doi.org/10.12968/denu.2011.38.6.376>.
26. Hayes M, Allen E, Da Mata C, McKenna G, Burke F. Minimal intervention dentistry and older patients Part 1: risk assessment and caries prevention. *Dental Update*. Published online. 2014; <https://doi.org/10.12968/denu.2014.41.5.406>.
27. Bartizek R, Gerlach R, Faller R, Jacobs S, Bollmer B, Biesbrock A. Reduction in dental caries with four concentrations of sodium fluoride in a dentifrice: a meta-analysis evaluation. *J Clin Dent*. 2001;12(3):57.
28. Kossioni AE, Hajto-Bryk J, Janssens B, et al. Practical guidelines for physicians in promoting oral health in frail older adults. *J Am Med Dir Assoc*. 2018;19(12) <https://doi.org/10.1016/j.jamda.2018.10.007>.
29. Slot D, Vaandrager N, Van Loveren C, Van Palenstein Helderma W, Van Der Weijden GA. The effect of chlorhexidine varnish on root caries: a systematic review. *Caries Res*. 2011;45(2).
30. Grandjean M, Maccarone N, McKenna G, Muller F, Srinivasan M. Silver Diamine Fluoride (SDF) in the management of root caries in elders: a systematic review and meta-analysis. *Swiss Dent J*. 2021;131(5).
31. Jabir E, McGrade C, Quinn G, et al. Evaluating the effectiveness of fluoride varnish in preventing caries amongst long-term care facility residents. *Gerodontology*. Published online May 24, 2021; <https://doi.org/10.1111/ger.12563>.
32. Wefel JS, Clarkson BH, Heilman JR. Natural root caries: a histologic and microradiographic evaluation. *J Oral Pathol Med*. 1985;14(8) <https://doi.org/10.1111/j.1600-0714.1985.tb00538.x>.
33. Hayes M, Brady P, Burke FM, Allen PF. Failure rates of class V restorations in the management of root caries in adults – a systematic review. *Gerodontology*. 2016;33(3) <https://doi.org/10.1111/ger.12167>.
34. de Moor RJG, Stassen IG, van 't Veldt Y, Torbeyns D, Hommez GMG. Two-year clinical performance of glass ionomer and resin composite restorations in xerostomic head- and neck-irradiated cancer patients. *Clin Oral Investig*. 2011;15(1) <https://doi.org/10.1007/s00784-009-0355-4>.
35. Meurman JH, McKenna G, Murtomaa H, et al. Managing our older population: the challenges ahead. *J Dent Res*. 2018;97(10) <https://doi.org/10.1177/0022034518784916>.
36. Petersen P, Kandelman D, Arpin S, Ogawa H. Global oral health of older people – call for public health action. *Community Dent Health*. 2010;27:252–62.
37. Frencken JE, Peters MC, Manton DJ, Leal SC, Gordan V, v., Eden E. Minimal intervention dentistry for managing dental caries – a review. *Int Dent J*. 2012;62(5) <https://doi.org/10.1111/idj.12007>.
38. da Mata C, Allen PF, McKenna G, Cronin M, O'Mahony D, Woods N. Two-year survival of ART restorations placed in elderly patients: a randomised controlled clinical trial. *J Dent*. 2015;43(4) <https://doi.org/10.1016/j.jdent.2015.01.003>.
39. de Amorim RG, Frencken JE, Raggio DP, Chen X, Hu X, Leal SC. Survival percentages of atraumatic restorative treatment (ART) restorations and sealants in posterior teeth: an updated systematic review and meta-analysis. *Clin Oral Investig*. 2018;22(8) <https://doi.org/10.1007/s00784-018-2625-5>.
40. da Mata C, Cronin M, O'Mahony D, McKenna G, Woods N, Allen PF. Subjective impact of minimally invasive dentistry in the oral health of older patients. *Clin Oral Investig*. 2015;19(3) <https://doi.org/10.1007/s00784-014-1290-6>.

41. da Mata C, Allen PF, Cronin M, O'Mahony D, McKenna G, Woods N. Cost-effectiveness of ART restorations in elderly adults: a randomized clinical trial. *Community Dent Oral Epidemiol.* 2014;42(1) <https://doi.org/10.1111/cdoe.12066>.
42. Lundberg A, Hillebrecht A, McKenna G, Srinivasan M. COVID-19: impacts on oral health-care delivery in dependent older adults. *Gerodontology.* 2021;38(2) <https://doi.org/10.1111/ger.12509>.
43. McKenna G, Janssens B, Srinivasan M, Brocklehurst P, Tsakos G. Who is caring for the oral health of dependent institutionalised elderly during the COVID-19 pandemic? *Gerodontology.* 2020;37(4) <https://doi.org/10.1111/ger.12504>.
44. Gil-Montoya JA, Mateos-Palacios R, Bravo M, González-Moles MA, Pulgar R. Atraumatic restorative treatment and Carisolv use for root caries in the elderly: 2-year follow-up randomized clinical trial. *Clin Oral Investig.* 2014;18(4) <https://doi.org/10.1007/s00784-013-1087-z>.
45. Göstemeyer G, da Mata C, McKenna G, Schwendicke F. Atraumatic vs conventional restorative treatment for root caries lesions in older patients: meta- and trial sequential analysis. *Gerodontology.* 2019;36(3) <https://doi.org/10.1111/ger.12409>.
46. Tonetti MS, Bottenberg P, Conrads G, et al. Dental caries and periodontal diseases in the ageing population: call to action to protect and enhance oral health and well-being as an essential component of healthy ageing – consensus report of group 4 of the joint EFP/ORCA workshop on the boundaries be. *J Clin Periodontol.* 2017;44 <https://doi.org/10.1111/jcpe.12681>.
47. Allen PF, McKenna G, Creugers N. Prosthodontic care for elderly patients. *Dent Update.* 2011;38(7) <https://doi.org/10.12968/denu.2011.38.7.460>.
48. McKenna G, Allen F, Woods N, et al. Cost-effectiveness of tooth replacement strategies for partially dentate elderly: a randomized controlled clinical trial. *Community Dent Oral Epidemiol.* 2014;42(4) <https://doi.org/10.1111/cdoe.12085>.