Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/sdj

Scientific Article

Factors contributing to tooth loss among the elderly: A cross sectional study

Zuhair S. Natto[a,b,*], Majdi Aladmawy[a], Mohammed Alasqah[a], Athena Papas[c]

[a]Department of Periodontology, Tufts University School of Dental Medicine, One Kneeland Street, Boston, MA 02111, USA
[b]Department of Dental Public Health, King Abdualziz University, School of Dentistry, Jeddah, Saudi Arabia
[c]Division of Dental Public Health Research and Oral Medicine, Tufts University School of Dental Medicine, Boston, MA 02111, USA

ARTICLE INFO

Keywords:
Aged
Periodontal disease
Teeth loss
Factors

ABSTRACT

Background: The present study evaluates the influence of several demographic, health, personal, and clinical factors on the number of missing teeth in old age sample.
Methods: The number of patients included was 259; they received a full mouth examination and answered a questionnaire provided by one examiner. All the variables related to teeth loss based on the literature were included. These variables focused on age, gender, race, marital status, clinical attachment level, pocket depth, year of smoking, number of cigarettes smoked per day, number of medications, root decay, coronal decay, health status, and year of education. Statistical analysis involved stepwise multivariate linear regression.
Results: Teeth loss was statistically associated with clinical attachment level (CAL)(p value 0.0001), pocket depth (PD) (0.0007) and education level (0.0048). When smoking was included in the model, age was significantly associated with teeth loss (0.0037). At least one of these four factors was also related to teeth loss in several specific groups such as diabetes mellitus, male, and White. The multiple linear regressions for all the proposed variables showed that they contributed to teeth loss by about 23%.
Conclusions: It can be concluded that less education or increased clinical attachment level loss may increase number of missing teeth. Additionally, age may cause teeth loss in the presence of smoking.

Introduction

Tooth loss in elderly population, was reported by several studies in the past, showing a strong association with mortality [1-3]. Periodontitis is considered as one of the etiologic factors contributing to tooth loss, it is hypothesized that the environment in the subgingiva plays a role on what type of microbial flora will flourish in that area, this elicits and inflammatory response from the host, which drives the condition from health to disease [4]. Several factors such as bleeding, deep probing, clinical attachment level increase and bone loss, eventually lead to tooth loss [5]. Periodontal breakdown of a crowned tooth structure is the most common reason contributing to tooth loss (59%) [6], other factors that

*Corresponding author. Tel.: +1 909 702 4119; fax: +1 617 636 0911.
E-mail address: zuhair.natto@tufts.edu (Z.S. Natto).

http://dx.doi.org/10.1016/j.sdj.2014.11.002
0377-5291/

contribute to tooth loss or extractions include un-restorable teeth (either from fractures or caries) (27%), or periapical lesions (12%), however 35.6% of the teeth extracted had an endodontic treatment [6]. Anand et al. reported on extraction trends in India, caries was observed as the main etiologic factor for extraction at 44%, periodontal breakdown at 33%, Orthodontic reasons at 11%, impactions and prosthodontics purposes were at 2% [7]. Reports from previous studies stated that periodontitis is associated with coronary heart disease [8] and diabetes mellitus [9,10].

Genco et al. [11] found an association between various markers of periodontitis and cardiovascular disease (CVD). A good oral hygiene is needed to reduce the mortality risk among elderly population. It was reported that people who maintain good oral hygiene, and visit the dentist at least once a year, had a lower mortality risk when compared with people who did not have good oral hygiene maintenance [12,13]. However, elderly patients with periodontal disease need to have a more aggressive therapy than what is commonly practiced [14].

Rosén et al. found that, patients who did not visit their dentists at least once annually were more susceptible to periodontal progression [15]. Other studies found that, the use of dentures had a relationship with reduction of mortality rates for older patients, who are missing teeth; this can be explained by the reduction of teeth that can harbor specific ecology group of micro-organisms that might have an association with systemic conditions [16–18].

Bachwald et al. examined the relationship between individual income status, and chronic systemic inflammation, to assess the progression of periodontal disease and tooth loss in Pomerania, Germany, 2566 participants had a 5 year follow up. They concluded that there was an association between individual income status and periodontitis, as the income decreased the progression of periodontitis was more evident [19].

Linden et al. reported that age was found to be associated with tooth loss, due to the progressive loss of attachment level [20]. Renvert et al. in 2013 found that, prevalence of probing depth more than, or equal to 5 mm with radiographic bone loss more than 5 mm increased with age, regardless of frequent dental visits [21].

Chen et al. 2012 found that coronal root caries, and removable dentures had a synergistic effect on tooth loss in the old population; patients who wore dentures had multiple carious areas, when the areas were treated they had the highest risk of tooth loss [22].

Tooth loss is associated with a lower quality of life due to more bacterial accumulation around the sulcus of the teeth, and/or the dentures [23]. Chronic inflammation contributes to the formation of diseases like coronary disease, stroke, hypertension, diabetes mellitus, and chronic obstructive pulmonary disease [24].

There are limited studies that report on tooth loss with different variables such as education level, race, age, smoking, coronal caries, and number of medications. In the Linden et al. study [20], the final outcome reported was mortality; in contrast to what is being researched in the current study, which is tooth loss. Previously mentioned studies [19–24] reported on one or two of the following variables: education level, race, age, smoking, coronal caries, and number of medications; however, there was no study that combined all of those variables as a multi-variable interaction.

Teeth maintenance in elderly population deserves some attention as it increases the quality of life, which requires a stable dentition to aid in food digestion [25], having tooth loss might decrease the quality of life for the patient.

The aim of our current study is to evaluate if there is an association between, tooth loss and several other variables like coronal root caries, smoking, patient education level, race, diabetes, medication use, and age.

Materials and methods

The volunteers recruited for this study came from either Tufts Geriatric Outreach program (57% of participants) or Tufts dental clinics (43%). The Tufts Geriatric Outreach program performs dental screening, nutritional screening, and educational sessions for elderly people and is conducted at 30 different locations in the greater Boston area.

Selection criteria for enrollment in the study included being a community dwelling resident, having six or more teeth, being free from wasting illness (endocrine disease that would affect nutrition; recent unexplained weight loss; and active alcoholism), and being willing and able to complete a 3-d food diary in a predetermined manner. Each participant signed a consent form agreeing to participate in the study. The study was approved by the Human Investigation Review Committee of Tufts University.

Clinical oral examinations were conducted at Tufts University School of Dental Medicine by one examiner using artificial light, explorer, mirror, and air syringe. The teeth were dried before examination to assess the dental decay. The coronal and root caries and periodontal measurements were made on all subjects according to the diagnostic criteria used in the US adult survey [26]. Third molars were excluded from examination. Training and calibration sessions to standardize caries and periodontal measurements based on the diagnostic criteria used in the US adult survey [26] were held semi-annually. Intraclass correlation coefficients for clinical attachment level and probing depth were 0.92 and 0.88, respectively. Self-administered questionnaires on general and health knowledge, attitudes and behavior, and medication history were also administered.

Sample size

We expected to have 95% power based on squared multiple correlation ρ^2 of 0.1, effect size of 0.11 and 10 predictors, a sample size of 195, and α=0.05. We expect about 20% drop out due to age of the participants. So, the total sample size was at least 245. The sample size was calculated using G*power software, version 3.1 (University Kiel, Germany).

Statistical analysis

Descriptive statistics were expressed as mean$\pm$SD or N (%). Univariate analysis and the stepwise model selection technique determined the significant variables that are more commonly associated with actual number of teeth loss.

Table 1 – Descriptive statistics of the study sample.

Variable	N=259
Age (mean±SD)	72.41±15.43
Gender, *n* (%)	
Male	108(44.08)
Female	137(55.92)
Race, *n* (%)	
White	218(89.71)
African American	25(10.29)
Marital status, *n* (%)	
Single	55(22.63)
Married	126(51.85)
Others	62(25.51)
Clinical attachment level (CAL) (mean±SD)	3.33±1.02
Clinical attachment level (CAL) *n* (%)	
≥3 mm	107(41.31)
<3 mm	152(58.69)
Pocket depth (mean±SD)	2.01±0.43
Pocket depth, *n* (%)	
≥3 mm	252(97.30)
<3 mm	7(2.70)
Years of smoking (mean±SD)	4.92±12.53
Number of cigarette per day	85420.90± 137382.52
Number of medications	0.72±1.57
Missing teeth	8.73±7.00
Root decay	0.39±1.12
Coronal decay	0.64±2.35
Total decay (root+coronal)	1.02±2.81
Disease, *n* (%)	
CVD	63(24.32)
Diabetes	47(18.15)
Medical stable	149(57.53)
Years of education (mean±SD)	13.36±2.46

Table 2 – Simple linear regression (univariate) analysis for all groups when teeth loss was associated with several demographic, health, personal and clinical factors.

Group and variable	*P* value	estimate	SE	R^2
All: excluding smoking				
Mean CAL	0.0001*	1.73290	0.44054	0.066
Mean PD	0.0007*	−3.84605	1.11906	0.115
Education	0.0048*	−0.54821	0.19254	0.147
All: including smoking				
Age	0.0037*	0.17869	0.06035	0.071
CVD				
None	–	–	–	–
DM				
Mean CAL	<0.0001*	5.54010	1.13992	0.396
Medically stable				
None	–	–	–	–
Male				
Mean CAL	<0.0001*	2.57647	0.58867	0.164
Mean PD	0.0006*	−5.33759	1.49555	0.261
Age	0.0075*	0.11748	0.04303	0.314
Female				
None	–	–	–	–
White				
Mean CAL	0.0002*	1.71620	0.45805	0.067
Mean PD	0.0010*	−4.39621	1.31887	0.117
African American				
None	–	–	–	–

* *P* value<0.05.

Multiple linear regressions were used to assess potential associations of actual number of teeth loss and several variables. The multicollinearity was checked. The adjustment and adequation of the final model was checked by the $C(p)$, and R^2 adjusted. Analyses were performed using SAS 9.3 (SAS Institute, Cary NC).

Results

Table 1 shows the demographic features of the study, the prevalent population was female, white, married, completed 13 years of education, and is about 72 years old. The population had deeper clinical attachment level (≥3 mm) and shallower pocket depth (<3 mm).

Variables associated with actual number of teeth loss

Actual number of teeth loss was statistically associated with clinical attachment level (*p* value 0.0001), pocket depth (0.0007) and education (0.0048) (Table 2). Number of teeth loss increased with more recession, less pocket depth, and less education. When smoking was included in the model, age was significant and positively associated with teeth loss (0.0037). At least one of these four factors was also related to number of teeth loss in several specific groups such as diabetes mellitus, male, and White.

Full model associated with actual number of teeth loss

In further analyses, multiple linear regression with smoking excluded due to number of missing, the variables clinical attachment level, pocket depth and education were significant (Table 3). Other variables indicated that tooth loss was higher with increased number of medications and root caries. Single, African American, females that had diabetes or cardiovascular disease, were more likely to demonstrate increased tooth loss. Adding smoking to the model which reduced the total subject to 146 due to case wise deletion characteristic of multiple linear regression, showed the same result, except more teeth loss was observed with increased coronal caries and among married population (Table 4). Both models found that these variables together explained bout 23% of factors associated with teeth loss.

Discussion

This study had a population of (44%) males compared to females (56%), most of the population was white (90%), and almost half of the population was married (52%).

Table 3 – Multiple linear regression analysis when teeth loss was associated with all demographic, health, personal and clinical factors excluding smoking.

Variable	*P* value	estimate	SE	R^2
Intercept	0.2521	5.57695	4.85635	
Number of medication	0.0419	0.67996	0.33216	
African American vs. White	0.1318	2.31266	1.52853	
Female vs. male	0.1393	1.35147	0.91052	
Mean CAL	<0.0001*	2.25749	0.51155	
Mean PD	0.0008*	−4.00146	1.17242	
Age	0.0469	0.06359	0.03181	
Education	0.0187*	−0.46014	0.19405	
Root caries	0.7468	0.1333	0.41238	
Coronal caries	0.8628	−0.03147	0.18181	
CVD vs. medically stable	0.0946	1.86617	1.11116	
DM vs. medically stable	0.3544	1.13126	1.21877	
Married vs. single	0.8409	−0.90663	1.10113	
Other vs. single	0.2876	0.27006	1.34364	
				0.2284

Other includes: divorced and widow.
*P value < 0.05.

Table 4 – Multiple linear regression analysis when teeth loss was associated with all demographic, health, personal and clinical factors including smoking.

Variable	*P* value	Estimate	SE	R^2
Intercept	0.5944	4.27353	8.00098	
Number of medication	0.1002	0.61305	0.36954	
African American vs. White	0.0854	4.22634	2.4332	
Female vs. male	0.6541	0.58244	1.29606	
Mean CAL	0.0655	1.22509	0.658	
Mean PD	0.057	−2.89193	1.5018	
Age	0.1177	0.10955	0.06943	
Education	0.0517	−0.53849	0.27347	
Root caries	0.7346	0.14641	0.43072	
Coronal caries	0.8062	0.04675	0.19007	
CVD vs. medically stable	0.2359	1.84542	1.54752	
DM vs. medically stable	0.896	0.23005	1.75596	
Married vs. single	0.6291	0.83191	1.71727	
Other vs. single	0.2598	2.26903	2.00233	
Total smoking	0.4006	0.0000041	0.000005	
				0.2383

P value < 0.05.
Other includes: divorced and widow.

It was found that tooth loss was associated with (a) increased clinical attachment level (CAL), (b) decreased probing depth (PD), and (c) less education level. When a tooth has increased CAL, it is less associated with the bone structure, PDL, and connective tissue, this increases its mobility and susceptibility to infection from bacteria due to the exposed dental tubules and apical migration, as the CAL progresses it causes the probing depth to decrease, hence we get shallower pocket depth.

Patient education was statically significant with tooth loss, when the population was more educated they had more teeth present, in contrast to the population with lower education that tended to have more teeth loss, our findings in patient education agreed with the findings from Buchwald et al. that reported Low education levels and low individual income were associated with higher chances of tooth loss [19].

Smoking and age were found to have a significant effect on tooth loss; hence if an individual was smoking and aging, he will have a higher chance of losing teeth compared to non-smokers. Ando et al. found that smoking, low education level, and poor nutritional status, had an association with tooth loss among middle-aged and elderly Japanese population [27], this agrees with our findings in the current study.

De Marchi et al. reported on a combination of factors that might influence tooth loss such as being old, male, married, living in the countryside, with less education, and was not satisfied with methods to obtain health services. All of the previous factors were associated with tooth loss [28].

Another study that has a different result, regarding smoking and age affecting tooth loss, is a study by Jiang et al., who studied the adult population in Rhode Island, and found

individuals that smoked had a high chance of losing teeth, and age was not related to tooth loss [29].

Being a white, male, and smoking increased the risk of tooth loss with increased CAL, decreased PD, and increased age. Diabetes mellitus (DM) was positively correlated to tooth loss with smoking, Meisel et al. in Germany found C-reactive protein (CRP), and other inflammatory mediators were elevated due to chronic inflammation, which affects the bone hemostasis and results in bone resorption around areas that involve the tooth structure [30].

Increasing the number of medications taken daily was also significant (without the smoking variable) to tooth loss incidence. Taking too many medications has a negative effect on the salivary glands, it reduces its function, and it favors more bacterial accumulation. Locker et al. reported that xerostomia has an important influence on the quality of life of the population [31].

When caries activity is associated with the root dentine, it produced a positive relation to tooth loss, as restoring these teeth becomes more challenging than restoring caries in the enamel surface, the main reason for tooth loss was the persistence of periodontal disease, followed by smoking, however when root caries was involved, it had an additional cause to tooth loss [32].

Caries in the crown area has less association with tooth loss. Both variables were not significant ($p=0.746$ root, $p=0.862$ crown caries) but it showed positive and negative correlations respectively to tooth loss. Imazato et al. reported on root caries among elderly population and concluded that root caries was more prevalent with patients that are taking increased number of medications, which induces xerostomia [33].

When we combine multiple variables like Married (M) vs. Single (S) there was a negative correlation to tooth loss, being single has a positive relation to tooth loss. African American (AM) vs. white had a positive relation to tooth loss. DM or CVD had positive relation to tooth loss.

When smoking variable was excluded in Table 3, it was found that CAL, PD, and EL variables were still statistically significant to tooth loss, however the PD had a negative relation because, as the tooth losses more bone support the distance from the gingival margin to the apex of the root decreases, hence the decrease in PD, this gives the negative relation right before the tooth is lost. The remaining variables in the table were not significant alone; however, when all are combined it can give a significant positive correlation to tooth loss. When we add smoking to the variables S, AM, and DM/CVD, it will enhance the positive correlation to tooth loss (up to 23%).

There are some limitations to the current study, (a) small sample size, (b) sample not representative as we got a convenient sample, and (c) lack of other studies that have the same study design with similar variables to compare the results.

We found that it might be beneficial to increase awareness and education, as this would help in encouraging the dwelling community to take a better care of their oral cavity. A regular dental visit helps to further maintain the teeth. Senior citizens that smoke are at an increased risk from losing their dentition. There should be a consideration when taking many medications as it can lead to a decrease in the salivary flow, which might induce more caries formation on the tooth and root. It is important to try and maintain teeth at a healthy state to have a good quality of life, especially in elderly population. A good masticatory performance or dietary intake is associated with good oral health status [34]. This study enables us to understand how different individual variables can interact with each other to result in an outcome of tooth loss.

Conclusion

It can be concluded that less education or more clinical attachment level loss may increase number of missing teeth. Additionally, age may cause teeth loss in the presence of smoking. Other variables indicated tooth loss was higher with increased number of medications, root decreased coronal caries. Also it was found that Single African American females, that had diabetes or cardiovascular disease were more likely to demonstrate increased tooth loss. It is important to maintain teeth in a healthy status, to increase the quality of life among elderly population. However, we need a bigger sample size to further investigate this relationship.

Conflict of interest

None declared.

REFERENCES

[1] C.C. Abnet, Y.L. Qiao, S.M. Dawsey, et al., Tooth loss is associated with increased risk of total death and death from upper gastrointestinal cancer, heart disease, and stroke in a Chinese population-based cohort, Int. J. Epidemiol. 34 (2005) 467–474.
[2] P. Holm-Pedersen, K. Schultz-Larsen, N. Christiansen, et al., Tooth loss and subsequent disability and mortality in old age, J. Am. Geriatr. Soc. 56 (2008) 429–435.
[3] A. Holmlund, G. Holm, L. Lind, Number of teeth as a predictor of cardio-vascular mortality in a cohort of 7674 subjects followed for 12 years, J. Periodontol. 81 (2010) 870–876.
[4] P.M. Bartold, T.E. Van Dyke, Periodontitis: a host-mediated disruption of microbial homeostasis. Unlearning learned concepts, Periodontology 62 (2013) (2000) 203–217.
[5] G.C. Armitage, P.B. Robertson, The biology, prevention, diagnosis and treatment of periodontal diseases: scientific advances in the United States, J. Am. Dent. Assoc. 140 (2009) 36S–43S.
[6] I. Dikbas, J. Tanalp, C.O. Tomruk, T. Koksal, Evaluation of reasons for extraction of crowned teeth: a prospective study at a university clinic, Acta Odontol. Scand. 71 (3–4) (2013) 848–856.
[7] P.S. Anand, K.P. Kamath, B. Nair, Trends in extraction of permanent teeth in private dental practices in Kerala state, India, J. Contemp Dent. Pract. 11 (3) (2010) 041–048.
[8] S.J. Janket, A.E. Baird, S.K. Chuang, et al., Meta-analysis of periodontal disease and risk of coronary heart disease and stroke, Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 95 (2003) 559–569.

[9] I.L.C. Chapple, R. Genco, Working Group 2 of the Joint EFP/AAP Workshop, Diabetes and periodontal diseases: consensus report of the Joint EFP/AAP workshop on periodontitis and systemic diseases, J. Clin. Periodontol. 40 (2013) S10.
[10] Z.S. Natto, M.S. Al-Zahrani, Periodontal bone loss and self-reported medical conditions in a dental school patient population, J Int Acad Periodontol. 12 (2010)104-109.
[11] R. Genco, S. Offenbacher ,J. Beck J, Periodontal disease and cardiovascular disease: epidemiology and possible mechanisms, J Am Dent Assoc. 133 (2002) 14S–22S.
[12] A. Paganini-Hill, S.C. White, K.A. Atchison, Dental health behaviors, dentition, and mortality in the elderly: the leisure world cohort study, J. Aging Res. 2011 (2011) 1–10.
[13] C. Nicholls, Periodontal disease incidence, progression and rate of tooth loss in a general dental practice: the results of a 12-year retrospective analysis of patient's clinical records, Br. Dent. J. 194 (2003) 485–488.
[14] A. Holmén, E. Strömberg, M.L. Hagman-Gustafsson, I. Wårdh, P. Gabre, Oral status in home-dwelling elderly dependent on moderate or substantial supportive care for daily living: prevalence of edentulous subjects, caries and periodontal disease, Gerodontology 29 (2012) e503–e511.
[15] B. Rosén, G. Olavi, A. Badersten, A. Rönström, G. Söderholm, J. Egelberg, Effect of different frequencies of preventive maintenance treatment on periodontal conditions. 5-year observations in general dentistry patients, J. Clin. Periodontol. 26 (1999) 225–233.
[16] Y. Shimazaki, I. Soh, T. Saito, et al., Influence of dentition status on physical disability, mental impairment, and mortality in institutionalized elderly people, J. Dent. Res. 80 (2001) 340–345.
[17] M. Yoshida, H. Morikawa, M. Yoshikawa, et al., Eight-year mortality associated with dental occlusion and denture use in community-dwelling elderly persons, Gerodontology 22 (2005) 234–237.
[18] K. Fukai, T. Takiguchi, Y. Ando, et al., Mortality rates of community-residing adults with and without dentures, Geriatr. Gerontol. Int. 8 (2008) 52–159.
[19] S. Buchwald, T. Kocher, R. Biffar, A. Harb, B. Holtfreter, P. Meisel, Tooth loss and periodontitis by socio-economic status and inflammation in a longitudinal populationbased study, J. Clin. Periodontol. 40 (2013) 203–211.
[20] G.J. Linden, K. Linden, J. Yarnell, A. Evans, F. Kee, C.C. Patterson, All-cause mortality and periodontitis in 60–70-year-old men: a prospective cohort study, J. Clin. Periodontol. 39 (2012) 940–946.
[21] S. Renvert, R.E. Persson, G.R. Persson, Tooth loss and periodontitis in older individuals: results from the Swedish National Study on Aging and Care, J. Periodontol. 84 (2013) 1134–1144.
[22] X. Chen, J.J. Clark, S. Naorungroj, Length of tooth survival in older adults with complex medical, functional and dental backgrounds, J. Am. Dent. Assoc. 143 (2012) 566–578.
[23] Somsak K, Kaewplung O. The effects of the number of natural teeth and posterior occluding pairs on the oral health-related quality of life in elderly dental patients. Gerodontology. 2014, http://dx.doi.org/10.1111/ger.12112.
[24] S. Offenbacher, S.P. Barros, S. Altarawneh, J.D. Beck, Z.G. Loewy, Impact of tooth loss on oral and systemic health, Gen. Dent. 60 (2012) 494–500.
[25] M. Cornejo, G. Pérez, K.C. de Lima, E. Casals-Peidro, C. Borrell, Oral health-related quality of life in institutionalized elderly in Barcelona (Spain), Med. Oral Patol. Oral Cir. Bucal 18 (2) (2013) e285–e292.
[26] US Department of Health and Human Services, Washington, DC, 1987.
[27] A. Ando, M. Ohsawa, Y. Yaegashi, K. Sakata, K. Tanno, T. Onoda, K. Itai, F. Tanaka, S. Makita, S. Omama, K. Ogasawara, A. Ogawa, Y. Ishibashi, T. Kuribayashi, T. Koyama, A. Okayama, Factors related to tooth loss among community-dwelling middle-aged and elderly Japanese men, J. Epidemiol. 23 (2013) 301–306.
[28] R.J. De Marchi, J.B. Hilgert, F.N. Hugo, C.M. Santos, A.B. Martins, D.M. Padilha, Four-year incidence and predictors of tooth loss among older adults in a southern Brazilian city, Community Dent. Oral Epidemiol. 40 (2012) 396–405.
[29] Y. Jiang, C.A. Okoro, J. Oh, D.L. Fuller, Sociodemographic and health-related risk factors associated with tooth loss among adults in Rhode Island, Prev. Chronic Dis. 10 (2013) E45.
[30] P. Meisel, P. Wilke, R. Biffar, B. Holtfreter, H. Wallaschofski, T. Kocher, Total tooth loss and systemic correlates of inflammation: role of obesity, Obesity 20 (2012) 644–650.
[31] D. Locker, Dental status, xerostomia and the oral health-related quality of life of an elderly institutionalized population, Spec. Care Dent. 23 (2003) 86–93.
[32] N. Ravald, C.S. Johansson, Tooth loss in periodontally treated patients: a long-term study of periodontal disease and root caries, J. Clin. Periodontol. 39 (2012) 73–79.
[33] S. Imazato, K. Ikebe, T. Nokubi, S. Ebisu, A.W. Walls, Prevalence of root caries in a selected population of older adults in Japan, J. Oral Rehabil. 33 (2006) 137–143.
[34] S. Kazemi, G. Savabi, S. Khazaei, O. Savabi, A. Esmaillzadeh, A.H. Keshteli, P. Adibi, Association between food intake and oral health in elderly: SEPAHAN systematic review no. 8, Dent. Res. J. 8 (Suppl. 1) (2011) S15–S20.