International Journal of Dental Hygiene

Official Journal of the International Federation of Dental Hygienists

ORIGINAL ARTICLE

HK Yuen
Y Weng
SG Reed
LM Summerlin
RM Silver

Factors associated with gingival inflammation among adults with systemic sclerosis

Authors' affiliations:
HK Yuen, Department of Occupational Therapy, School of Health Professions, University of Alabama, Birmingham, AL, USA
Y Weng, Division of Biostatistics and Epidemiology, Department of Medicine, Medical University of South Carolina (MUSC), Charleston, SC, USA
SG Reed, *LM Summerlin*, Department of Pediatrics–Neonatology, College of Medicine, Medical University of South Carolina (MUSC), Charleston, SC, USA
RM Silver, Division of Rheumatology & Immunology, Department of Medicine, Medical University of South Carolina (MUSC), Charleston, SC, USA

Correspondence to:
H.K. Yuen
Department of Occupational Therapy
School of Health Professions
University of Alabama
1530 3rd Avenue South
Birmingham
AL 35294
USA
Tel.: +1 205 9346301
Fax: +1 205 9757787
E-mail: yuen@uab.edu

Dates:
Accepted 7 March 2013

To cite this article:
Int J Dent Hygiene **12**, 2014; 55–61.
DOI: 10.1111/idh.12024
Yuen HK, Weng Y, Reed SG, Summerlin LM, Silver RM. Factors associated with gingival inflammation among adults with systemic sclerosis.

Abstract: *Objective:* To identify factors associated with increased gingival inflammation in adults with systemic sclerosis (SSc, scleroderma). *Methods:* In this cross-sectional study, forty-eight adults with SSc received assessment of gingival inflammation using Löe and Silness gingival index (LSGI), measurement of oral aperture and evaluation of manual dexterity to perform oral hygiene using the Toothbrushing Ability Test, as well as completion of an oral health-related questionnaire. *Results:* Three explanatory variables in the final multiple predictor models for the LSGI outcome were statistically significant – manual dexterity to perform oral hygiene, flossing in the evening and SSc subtype, with higher (i.e., worse) LSGI score among those with impaired manual dexterity, not flossing in the evening and diffuse form of SSc. In addition, posterior teeth had higher LSGI scores compared with that of the anterior teeth after adjusting for other variables. *Conclusions:* Results suggest that dental health professionals take manual dexterity into consideration when educating patients with SSc to improve their oral hygiene and educate them on paying more attention on cleaning their posterior teeth and the importance of flossing in the evening – especially those who only floss once a day or less often.

Key words: epidemiological methods; gingival diseases; oral hygiene; scleroderma

Systemic sclerosis (SSc, scleroderma) belongs to a group of autoimmune connective tissue diseases and is characterized by inflammation, vascular dysfunction and excessive fibrosis of connective tissue supporting the skin and visceral organs (1, 2). SSc is classified into two main subtypes: limited and diffuse cutaneous SSc. Limited cutaneous SSc is characterized by restricted skin involvement (often just the hands and face), prominent vascular manifestations, exhibiting features of calcinosis, Raynaud's phenomenon, oesophageal dysmotility, sclerodactyly, telangiectasias (CREST) syndrome, and slow progression (3, 4). Diffuse cutaneous SSc is characterized by rapidly progressing symmetrical widespread skin involvement and visceral organ involvement (3, 4). In the United States, the ratio of limited to diffuse form of SSc is approximately 3:2 (5, 6).

SSc affects women about 3.8 times more than men (7). African Americans have a higher prevalence of SSc compared with Caucasian Americans and a higher incidence of the diffuse form compared with Caucasian Americans where the incidence of the limited form is more common (6, 8). African Americans also tend to develop SSc at an earlier age (typically 35–44 years of age) compared with 45–54 years of age in Caucasian Americans (5).

SSc affects the skin and musculoskeletal tissue on the hands as well as oral and perioral tissues (9–12). Manual dexterity impairments and

orofacial complications are two major clinical manifestations that may contribute to increased risk of oral health problems in people with SSc (13, 14). Typical sclerodermatous skin changes (thickening and tightness) involving the digits with progressive finger flexion and retraction may give the hand a 'claw-like' appearance (15). Flexion contractures of the proximal interphalangeal joints may limit tip-to-tip prehension, resulting in decreased dexterity (16). On average, manual dexterity in people with SSc is reduced by 25% and grip strength is reduced by 45% compared with values for healthy individuals (16); further, 90% of people with SSc in one study complain of loss of hand grasp ability (17).

Two principal orofacial manifestations that may complicate oral hygiene are microstomia (small mouth) and xerostomia (excessive dry mouth resulting from salivary hypofusion). Microstomia in SSc is mainly caused by submucosal collagen deposits, which contributes to fibrosis in perioral tissue (18). Anywhere from 43% to 80% of people with SSc display microstomia (14, 19, 20) with the mean interincisal distance for people with SSc being about 33 mm (14, 21–24). Xerostomia results from sclerosis of connective tissue in the salivary glands with or without a cellular infiltrate (secondary Sjogren's syndrome). Sicca symptoms (including dry mouth) are common in people with SSc (about 60%) (25–27).

In SSc, defective vascularity and alterations in the microcirculation of the gingival tissues may lead to gingival inflammation (28, 29). Additionally, several factors that hamper people with SSc from performing adequate oral hygiene methods, such as microstomia, decreased manual dexterity and hand deformity, may in turn lead to gingival inflammation. Dry mouth has been shown to promote the development of dental plaque and increase the risk of developing oral diseases (30–32), such as gingival inflammation induced by dental plaque (33, 34). Medications such as immunosuppressants and calcium channel blockers used to manage SSc complications are known to increase the risk of developing gingival hyperplasia (35), which may also increase the risk of gingival inflammation. In one study, gingival bleeding was present in about 60% of patients with SSc (14).

Although various SSc disease-related specific factors such as dry mouth, decreased oral aperture and manual dexterity impairment that may relate to gingival inflammation have been described in the literature, few studies have investigated the association of these SSc disease-related factors with gingival inflammation in adults with SSc. There are several case–control studies indicating that when compared with age- and sex-matched healthy controls, people with SSc exhibited more severe gingival inflammation (36, 37), or a higher proportion of people with SSc showed a positive gingival bleeding index (14). Therefore, the purpose of the present study was to identify factors associated with increased gingival inflammation in adults with SSc. Identification of these factors (both SSc disease-related and amendable) is important in preventing and managing the gingival inflammation for this population. Findings can help the dental health professional tailor treatment procedures to better manage gingivitis, as well as to provide specific information that can be used to advise patients with SSc with gingival inflammation and poor oral hygiene. This is especially important with plaque-induced gingivitis, as this may lead to periodontal disease and tooth loss.

Methods

Participants

Participants eligible for this cross-sectional study were adults (aged > 18 years) diagnosed with SSc at least 1 year prior to study baseline evaluation, and who fulfilled the American College of Rheumatology preliminary classification criteria for SSc (3). Exclusion criteria were localized scleroderma (e.g. morphea, linear scleroderma and en coup de sabre), <10 natural teeth, an upper and/or lower full denture, complaint of any major jaw joint problems (e.g. severe pain or dislocation) or requirement for antibiotic therapy prior to dental examination. Details of the subject selection criteria have been reported elsewhere (24, 38).

Recruitment

One hundred and thirteen patients with SSc from the scleroderma clinic at the Medical University of South Carolina (MUSC), with record in the local connective tissue disease database (CTDD), were invited to participate to the study and if interested contacted either in person or by phone. The CTDD contains medical information on the majority of patients with SSc who received consultation and/or treatment at the university rheumatology clinic beginning in 2001. Forty-eight eligible participants completed the baseline assessment with a recruitment rate of 42.5%. Reasons for patients not completing the baseline assessment included the following: decline (46 patients), not meeting the selection criteria (11), unable to contact patients (after several attempts) to schedule an appointment (4), conflict with other medical needs (1), unable to take time off at work (1), fear of losing teeth (1) and deceased (1).

Procedures

One to two days before the study appointment, potential participants were contacted by phone and instructed not to perform any oral self-care procedures, nor to use chewing gum the evening and morning before the appointment. Informed consent was explained and completed, and the mouth evaluation was conducted at the MUSC Clinical Translational Research Center. The evaluation included an assessment of gingival inflammation, measurement of oral aperture and evaluation of manual dexterity to perform oral hygiene using the Toothbrushing Ability Test (TAT) (39, 40), as well as completion of an oral health-related questionnaire. Two trained and calibrated dental hygienists were designated as the oral health examiners and conducted the assessments (41). The protocol was approved by the MUSC Institutional Review Board.

Outcome variable

The Löe and Silness Gingival Index (LSGI) was used to estimate different degrees of inflammation in marginal gingiva (42). Gingival measures were made and scored for four areas of each natural tooth: mesial, distal, buccal and lingual. Each area was scored for gingivitis on a 0–3 ordinal scale according to the following criteria: 0 = normal gingiva or absence of inflammation; 1 = mild inflammation – slight change in colour, slight oedema and no bleeding on probing; 2 = moderate inflammation – redness, oedema, glazing and bleeding on probing; and 3 = severe inflammation – marked redness and oedema, ulceration and tendency to spontaneous bleeding. The LSGI scores were formed from a maximum of 28 teeth in each participant (third molars excluded).

Explanatory variables

Manual dexterity to perform oral hygiene was assessed by the Toothbrushing Ability Test (TAT) (39, 40). Detailed procedure and scoring have been described in the literature (39, 40). Briefly, participants were requested to brush the front surfaces of all lower front teeth (i.e. from canine to canine) in 30 seconds using a regular manual toothbrush. After being stained, three anterior mandibular teeth (i.e. #22, #25 and #27) were scored according to Patient Hygiene Performance (PHP) criteria (43). The score of the TAT ranges from 0 to 19 with a score >6 indicating manual dexterity impairments. Using this cut-off value, the sensitivity and specificity of TAT in predicting adequate brushing ability are 90% and 75%, respectively (39, 40). Among several common standardized manual dexterity tests, TAT has been shown to be the best predictor for plaque score (39, 40). The TAT with scores above 6 was coded as '1', indicating manual dexterity impairment to perform oral hygiene, and scores between 0 and 6 was coded as '0', indicating no impairment. Based on the analysis of data from 25 adults with connective tissue disorders who had their PHP evaluated simultaneously by the two dental hygienists in the present study, the intraclass correlation coefficient (ICC) for the inter-rater reliability on the TAT exceeded 0.72, which indicates acceptable agreement.

Maximum oral aperture was measured, using a small metal ruler, as the vertical distance in millimetre between the incisal edges of the maxillary and mandibular right central incisors when the participants were requested to open their mouths as wide as possible (44). If the right central incisors were absent, the left central, right lateral or left lateral incisors were substituted in that order (44). Three successive trials of maximum oral aperture measurement, with a 5-s pause in between each measurement, were conducted and recorded (45). An average of the three successive trials for each oral aperture measurement was computed. The inter-rater reliability for the measurement of the size of oral aperture was excellent with ICC = 0.99 (24).

The oral health-related questionnaire contained items addressing the demographic and socio-economic characteristics of the participants, as well as their dental care visit patterns, oral hygiene behaviours, dry mouth symptoms, smoking and soda consumption habits. Demographic and socio-economic characteristics included age, gender, race (African American or Caucasian American), marital status (married/live together or unmarried), education, employment status (paid employment or not employed), annual household income and dental insurance (private/public-funded or none). Dental visits in the past year were re-coded as 'yes/1' or 'no/0'. Brushing habits were indicated by brushing at least twice daily versus less often and whether brushing in the evening or not. Flossing habit was indicated by flossing at least once a day versus less often and whether flossing in the evening or not. Mouth rinsing habits were indicated by using mouth rinse at least once a day versus less often. Other questions related to oral hygiene included use of oral irrigator and difficulty flossing teeth.

The presence of dry mouth symptoms (coded as '1') was indicated by a positive response to one or more of the following four questions (46): 'Do you sip liquids to aid in swallowing dry foods?'; 'Does your mouth feel dry when eating a meal?'; 'Do you have difficulties swallowing any foods?'; and 'Does the amount of saliva in your mouth seem to be too little?' Participant's smoking was indicated by current, past smoking habits or designated as non-smoking by 'never smoked'. Soda consumption was quantified by the number of 12-ounce non-diet sodas consumed in a typical day.

Specific medical history including SSc disease subclassification (i.e. limited or diffuse form), disease duration, medical comorbidities such as sicca syndrome, gastro-oesophageal reflux disease (GERD) and joint problems in the hand, and medications such as immunosuppressants and calcium channel blockers were obtained from patient medical records. The presence or absence of each comorbidity was dichotomously coded.

Data analysis

The main outcome for the primary analysis was subject-level gingival inflammation, represented by the average LSGI score over all available surfaces in the whole mouth, excluding third molars. In the preliminary analysis, we performed unadjusted bivariate analysis to explore any significant associations between the main outcome and explanatory variables.

For the adjusted analysis, we fit a multivariable linear regression model. We considered variables for inclusion in the final model if they are significantly associated with LSGI score ($P < 0.10$) in the unadjusted analyses. To avoid problems caused by collinearity, if two or more variables are highly correlated ($r > 0.3$), we would select the most appropriate one based on the clinical justification. A backward stepwise procedure for model building was used to obtain the most parsimonious model.

In addition to the primary analyses, we performed secondary data analyses to compare the mean LSGI score between anterior teeth (i.e. #6-#11 and #22-#27) and posterior teeth (#2-#5, #12-#15, #18-#21 and #28-#31). As LSGI scores from the two locations in each subject cannot be presumed independent, we

fit a multilevel model using Proc Mixed in SAS with anterior and posterior LSGI scores nested within each individual, a site indicator (anterior vs. posterior teeth) as fixed effect and variables from the primary multivariable linear regression as covariates. In the multilevel model, we assumed the measures for the two locations have a common variance, but their covariance can be non-zero. SAS 9.2 (SAS Institute Inc., Cary, NC, USA) was used for all data analyses in this study.

Results

Table 1 shows the characteristics of the 48 participants, which include their diagnosis, comorbidities, medications, socio-demographics and oral health-related behaviour information. The mean oral aperture of the participants was <40 mm, which is classified as microstoma (44). About three-fourth of the participants reported having dry mouth symptoms (73%) or demonstrated impairment in manual dexterity (75%) as indicated by their TAT score above six. The mean (SD) number of participants' teeth was 24.3 (4.0) with a range from 10 to 28. The mean (SD) number of missing teeth of the participants was 3.7 (4.0) with a range from 0 to 18.

From the unadjusted analyses, we observed significant associations between LSGI scores and the following variables: TAT score, SSc subtype, age, race, income, flossing in the evening, number of cans of non-diet sodas consumed in a day and dental visit last year. Table 2 shows the unadjusted analyses results for these variables. In addition, we found that age and race were highly correlated with type of SSc and that income was highly correlated with flossing in the evening and dental visit last year. To reduce the effect of multicollinearity, age, race and income were excluded from the multivariable analysis, as these variables did not belong to the disease of SSc or oral health behaviours.

Based on a backward stepwise procedure, we set up the multivariable model. From our univariate analyses, we included four variables in our multivariable model: TAT score, SSc subtype, evening flossing and number of cans of non-diet sodas consumed in a day. Although the estimate of soda consumption was insignificant, we still kept it in the model, because removing this variable could lead to 1) significant variations (>10%) in the estimated coefficients for the other variables and 2) a significant decline (10%) in the adjusted R^2. With the four variables included, the adjusted R^2 for the final model was 0.31. The final model indicated that TAT score, SSc subtype and evening flossing are significantly associated with the average LSGI score for the whole mouth, with higher (i.e., worse) LSGI score among those with impaired manual dexterity, not flossing in the evening and diffuse form of SSc (see Table 3).

In the secondary data analyses, we fit a multilevel model for LSGI scores by location (anterior versus posterior teeth). We found that posterior teeth had higher LSGI scores compared with that of the anterior teeth after adjusting for other covariates (see Table 4). TAT score, SSc subtype and flossing evening remained significant predictors in the multilevel model.

Table 1. **Characteristics of the participants (*n* = 48)**

Characteristic	Mean ± SD (range) or *n* (%)
Diagnosis and comorbidities	
Diffuse cutaneous subtype	20 (41.7%)
Disease duration (years)*	7.6 ± 6.1 (1.0–24.7)
Oral aperture (mm)	36.5 ± 9.7 (10.0–56.7)
TAT score > 6 (i.e. manual dexterity impairment)	36 (75.0%)
Contractures (hand/wrist/elbow)	12 (25.0%)
Tender/swollen hand joints	15 (31.2%)
Gastro-oesophageal reflux disease	38 (79.2%)
Sicca syndrome	14 (29.2%)
Sjogren's syndrome	4 (10.4%)
Self-report dry mouth symptoms	35 (72.9%)
Drugs	
Secretagogue	3 (6.3%)
Calcium channel blocker	26 (54.2%)
Immunosuppressant	11 (22.9%)
Socio-demographics	
Age (years)	50.7 ± 13.0 (22–76)
Female	38 (79.2%)
African American†	26 (54.2%)
Married/live together	22 (45.8%)
Education (less than college)	27 (56.3%)
Employment (FT and PT)	18 (37.5%)
Not employed due to disability	14 (29.2%)
Annual income (< $20,000)	17 (35.4%)
Annual income (≥ $55,000)	17 (35.4%)
No dental insurance	19 (39.6%)
Private dental insurance	19 (39.6%)
Oral health-related behaviours	
Dental visit (in past 12 months)	33 (68.8%)
Brush teeth (once a day)	16 (33.3%)
Brush teeth (at least twice a day)	31 (64.6%)
Brush teeth (evening)	31 (64.6%)
Floss teeth (never)	6 (12.5%)
Floss teeth (once a day)	18 (37.5%)
Floss teeth (at least twice a day)	7 (14.6%)
Floss teeth (evening)	26 (54.2%)
Use mouth rinse (never)	12 (25.0%)
Use mouth rinse (once a day)	12 (25.0%)
Use mouth rinse (twice a day)	4 (8.3%)
Use an oral irrigator	5 (10.4%)
Have difficulty flossing back teeth	26 (54.2%)
Have difficulty using dental floss to floss teeth	26 (54.2%)
Non-smoker (current)	46 (95.8%)
Did not consume any cans of regular size non-diet soda yesterday	39 (81.3%)

FT, full time; PT, part time; SD, standard deviation; TAT, Tooth-brushing Ability Test.
*n = 42, due to missing data.
†Only African Americans and Caucasians.

Discussion

Manual dexterity to perform oral hygiene as measured by TAT, SSc subtype and flossing in the evening are the three explanatory variables that were significantly associated with the LSGI score in the final multiple predictor model. Manual dexterity to perform sufficient oral hygiene has been previously suggested to affect the oral health in people with SSc

Table 2. **Effects on LSGI scores from unadjusted analysis**

Variable	Estimate	SE	*P*-value
TAT score (impaired dexterity versus not impaired)	0.257	0.119	0.037
SSc subtype (limited versus diffuse)	−0.219	0.098	0.031
Age (1 year increase)	−0.009	0.004	0.015
Race (Caucasian versus African Americans)	−0.222	0.097	0.026
Income (1 unit increase)	−0.022	0.010	0.030
Evening flossing (Yes versus No)	−0.172	0.100	0.094
Cans of soda consumed in previous day (1 can increase)	0.194	0.070	0.008
Dental visit in the past 12 months (Yes versus No)	−0.197	0.106	0.069

SE, standard error; LSGI, Löe and Silness Gingival Index; TAT, Toothbrushing Ability Test.

Table 3. **Effects on LSGI scores from adjusted analysis by multivariable linear regression**

Variable	Estimate	SE	*P*-value
TAT score (impaired dexterity versus not impaired)	0.232	0.111	0.042
SSc subtype (limited versus diffuse)	−0.223	0.089	0.017
Evening flossing (Yes versus No)	−0.207	0.090	0.027
Cans of soda consumed in previous day (1 can increase)	0.108	0.065	0.106

SE, standard error; LSGI, Löe and Silness Gingival Index; TAT, Toothbrushing Ability Test.

Table 4. **Multivariate analysis for repeated measures of LSGI scores by teeth location**

Variable	Estimate	SE	*P*-value
Teeth location (posterior versus anterior)	0.106	0.028	0.001
TAT score (impaired dexterity versus not impaired)	0.239	0.110	0.036
SSc subtype (limited versus diffuse)	−0.217	0.089	0.019
Evening flossing (Yes versus No)	−0.219	0.090	0.020
Cans of soda consumed in previous day (1 can increase)	0.110	0.065	0.099

SE, standard error; LSGI, Löe and Silness Gingival Index; TAT, Toothbrushing Ability Test.

(13). For example, a longer duration period to complete a manual dexterity task was found to be associated with poorer oral hygiene as measured by the PHP index in people with SSc (13). However, case–control design studies usually do not isolate specific factors that affect gingival health of people with SSc (14, 36, 37). Findings from the present study suggest the importance of dental health professionals to take manual dexterity into consideration when educating patients with SSc to improve their oral hygiene. As powered toothbrushes have been shown to reduce gingival inflammation in patients with SSc (38), dental health professionals should consider recommending patients with SSc to use powered toothbrushes especially those with oscillating–rotating–pulsating feature to compensate for decreased manual dexterity. In addition, they may refer patients with SSc to an occupational therapist to improve manual dexterity by connective tissue massage of the hands, joint mobilization of the wrist as well as learning specific finger- and hand-stretching exercise (47, 48).

As flossing in the evening was shown to be significantly related to lower LSGI scores (less gingival inflammation), dental health professionals should educate patients with SSc on the importance of flossing in the evening, especially those who only floss once a day or less often. In the present study, about half of the study participants who flossed once a day or less often reported that they flossed in the evening (47.5% or 19 of 40). It is important for dental health professionals to discuss with patients with SSc who floss once a day or less often on barriers related to flossing more often and to perform flossing in the evening, as well as to explore alternative strategies for patients who do not floss. Strategies that may be acceptable for those who do not floss may include the use of an alternative interdental cleaning device such as an oral irrigator (49) or a non-alcohol based mouth rinse in the evening (50), which may help to reduce the gingival inflammation. In the present study, only 5 (10%) participants reported to use an oral irrigator and 16 (33%) use mouth rinse at least once a day.

Patients with the diffuse form of SSc were shown to be more at risk of gingival inflammation. However, no significant association between SSc subtype and any of oral health behaviour variables or TAT score was found. The cause of the gingival inflammation may be attributed to the defective vascularity and alterations in the microcirculation of the gingival tissues leading to gingival bleeding (28, 29).

Given that posterior teeth had higher (i.e., worse) LSGI scores compared with the anterior teeth, it is important for dental health professionals to emphasize to their patients the importance of brushing and flossing the posterior teeth. In the present study, more than half of the participants (54%) reported having difficulty using dental floss or flossing posterior teeth. Use of a children's toothbrush with a smaller bristle head may help some patients with microstomia (<40 mm oral aperture) to better access and clean their posterior teeth. In addition, an oral irrigator and an alcohol-free mouth rinse can serve as a supplement to oral hygiene practices.

A finding of interest in the present study was that age was negatively associated with LSGI scores among this group. As young age was also significantly associated with diffuse form of SSc subtype, this may partly explain the association of young age with worse LSGI score.

African Americans were the majority of participants (54.2%) in the present study. We acknowledge that the sample in this study is a convenience sample that may or may not represent the SSc population; however, it should be noted that the demographic characteristics (gender, type of SSc, incidence of limited and diffuse form of SSc among African- and Caucasian Americans, and mean age of SSc disease onset) of the participants in the present study are similar to those reported

in several large epidemiological studies conducted in the United States (5–7). For example, there were 3.8 times more women than men in the present study; the proportion of limited and diffuse form of SSc was 58.3% versus 41.7%; more African American participants were diagnosed with the diffuse form (57.7%), and more Caucasian American participants were diagnosed with the limited form (77.3%); and the mean age of SSc disease onset among African American participants was about 10 years younger than that of Caucasian American participants (37.7 versus 50.1 years of age). In addition, consistent with previous studies, there was no significant association between LSGI scores and GERD (51) or duration of SSc disease (37).

The present study investigated the factors that relate to gingival inflammation in people with SSc. Future studies including social determinants of gingival inflammation may reveal a more comprehensive picture towards understanding the oral health of people with SSc.

Acknowledgements

The authors wish to thank the dental hygienist Pemra L. Hudson, RDH, for conducting the oral examination, and the project coordinator Samantha Mahoney for subject recruitment and data entry. This study was supported by a grant awarded to the first author from the Scleroderma Foundation. Additional support was provided by the National Institute of Dental and Craniofacial Research (Grant # 1R21DE017360-01A2); the Multidisciplinary Clinical Research Center grant from the National Institute of Arthritis and Musculoskeletal and Skin Diseases, National Institutes of Health (Grant # P60 AR049459); the South Carolina Centers of Biomedical Research Excellence (COBRE) for Oral Health with funding provided by the National Institutes of Health (NIH) and the National Center for Research Resources (NCRR) with a P20 RR-017696; and the South Carolina Clinical & Translational Research Institute, Medical University of South Carolina's CTSA, NIH/NCRR Grant Number UL1RR029882.

Conflict of interest

The authors declare that they have no conflict of interest.

References

1 Derk CT, Jimenez SA. Systemic sclerosis: current views of its pathogenesis. *Autoimmun Rev* 2003; **2**: 181–191.
2 Dghoughi S, El Wady W, Taleb B. Systemic sclerosis. Case report and review of literature. *N Y State Dent J* 2010; **76**: 30–35.
3 Masi AT. Preliminary criteria for the classification of systemic sclerosis (scleroderma). Subcommittee for scleroderma criteria of the American Rheumatism Association Diagnostic and Therapeutic Criteria Committee. *Arthritis Rheum* 1980; **23**: 581–590.
4 LeRoy EC, Black C, Fleischmajer R *et al.* Scleroderma (systemic sclerosis): classification, subsets and pathogenesis. *J Rheumatol* 1988; **15**: 202–205.
5 Laing TJ, Gillespie BW, Toth MB *et al.* Racial differences in scleroderma among women in Michigan. *Arthritis Rheum* 1997; **40**: 734–742.
6 Reveille JD, Fischbach M, McNearney T *et al.* Systemic sclerosis in 3 US ethnic groups: a comparison of clinical, sociodemographic, serologic, and immunogenetic determinants. *Semin Arthritis Rheum* 2001; **30**: 332–346.
7 Steen VD, Oddis CV, Conte CG, Janoski J, Casterline GZ, Medsger TA Jr. Incidence of systemic sclerosis in Allegheny County, Pennsylvania. A twenty-year study of hospital-diagnosed cases, 1963–1982. *Arthritis Rheum* 1997; **40**: 441–445.
8 Mayes MD. Scleroderma epidemiology. *Rheum Dis Clin North Am* 2003; **29**: 239–254.
9 Alantar A, Cabane J, Hachulla E *et al.* Recommendations for the care of oral involvement in patients with systemic sclerosis. *Arthritis Care Res (Hoboken)* 2011; **63**: 1126–1133.
10 Albilia JB, Lam DK, Blanas N, Clokie CM, Sandor GK. Small mouths… Big problems? A review of scleroderma and its oral health implications. *J Can Dent Assoc* 2007; **73**: 831–836.
11 Fischer DJ, Patton LL. Scleroderma: oral manifestations and treatment challenges. *Spec Care Dentist* 2000; **20**: 240–244.
12 Skare TL, Toebe BL, Boros C. Hand dysfunction in scleroderma patients. *Sao Paulo Med J* 2011; **129**: 357–360.
13 Poole JL, Brewer C, Rossie K, Good CC, Conte C, Steen V. Factors related to oral hygiene in persons with scleroderma. *Int J Dent Hyg* 2005; **3**: 13–17.
14 Scardina GA, Messina P. Systemic sclerosis: description and diagnostic role of the oral phenomena. *Gen Dent* 2004; **52**: 42–47.
15 Poole JL. Grasp pattern variations seen in the scleroderma hand. *Am J Occup Ther* 1994; **48**: 46–54.
16 Sandqvist G, Eklund M, Akesson A, Nordenskiold U. Daily activities and hand function in women with scleroderma. *Scand J Rheumatol* 2004; **33**: 102–107.
17 Alpiner N, Oh TH, Hinderer SR, Brander VA. Rehabilitation in joint and connective tissue diseases. 1. Systemic diseases. *Arch Phys Med Rehabil* 1995; **76**: S32–S40.
18 Paquette DL, Falanga V. Cutaneous concerns of scleroderma patients. *J Dermatol* 2003; **30**: 438–443.
19 Eversole LR, Jacobsen PL, Stone CE. Oral and gingival changes in systemic sclerosis (scleroderma). *J Periodontol* 1984; **55**: 175–178.
20 Marmary Y, Glaiss R, Pisanty S. Scleroderma: oral manifestations. *Oral Surg Oral Med Oral Pathol* 1981; **52**: 32–37.
21 Chu CH, Yeung CM, Lai IA, Leung WK, Mok MY. Oral health of Chinese people with systemic sclerosis. *Clin Oral Investig* 2011; **15**: 931–939.
22 Mouthon L, Rannou F, Berezne A *et al.* Development and validation of a scale for mouth handicap in systemic sclerosis: the Mouth Handicap in Systemic Sclerosis scale. *Ann Rheum Dis* 2007; **66**: 1651–1655.
23 Sharma VK, Trilokraj T, Khaitan BK, Krishna SM. Profile of systemic sclerosis in a tertiary care center in North India. *Indian J Dermatol Venereol Leprol* 2006; **72**: 416–420.
24 Yuen HK, Marlow NM, Reed SG *et al.* Effect of orofacial exercises on oral aperture in adults with systemic sclerosis. *Disabil Rehabil* 2012; **34**: 84–89.
25 Avouac J, Sordet C, Depinay C *et al.* Systemic sclerosis-associated Sjogren's syndrome and relationship to the limited cutaneous subtype: results of a prospective study of sicca syndrome in 133 consecutive patients. *Arthritis Rheum* 2006; **54**: 2243–2249.
26 Swaminathan S, Goldblatt F, Dugar M, Gordon TP, Roberts-Thomson PJ. Prevalence of sicca symptoms in a South Australian cohort with systemic sclerosis. *Intern Med J* 2008; **38**: 897–903.

27 Salliot C, Mouthon L, Ardizzone M *et al*. Sjogren's syndrome is associated with and not secondary to systemic sclerosis. *Rheumatology (Oxford)* 2007; **46**: 321–326.
28 Ozcelik O, Haytac MC, Ergin M, Antmen B, Seydaoglu G. The immunohistochemical analysis of vascular endothelial growth factors A and C and microvessel density in gingival tissues of systemic sclerosis patients: their possible effects on gingival inflammation. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008; **105**: 481–485.
29 Scardina GA, Pizzigatti ME, Messina P. Periodontal microcirculatory abnormalities in patients with systemic sclerosis. *J Periodontol* 2005; **76**: 1991–1995.
30 Guggenheimer J, Moore PA. Xerostomia: etiology, recognition and treatment. *J Am Dent Assoc* 2003; **134**: 61–69; quiz 118-9.
31 Hase JC, Birkhed D. Salivary glucose clearance, dry mouth and pH changes in dental plaque in man. *Arch Oral Biol* 1988; **33**: 875–880.
32 Sreebny LM, Valdini A. Xerostomia. A neglected symptom. *Arch Intern Med* 1987; **147**: 1333–1337.
33 Loe H, Theilade E, Jensen SB. Experimental Gingivitis in Man. *J Periodontol* 1965; **36**: 177–187.
34 Trombelli L, Tatakis DN, Scapoli C, Bottega S, Orlandini E, Tosi M. Modulation of clinical expression of plaque-induced gingivitis. II. Identification of "high-responder" and "low-responder" subjects. *J Clin Periodontol* 2004; **31**: 239–252.
35 Seymour RA, Heasman PA. Drugs and the periodontium. *J Clin Periodontol* 1988; **15**: 1–16.
36 Leung WK, Chu CH, Mok MY, Yeung KW. *Ng SK*. Periodontal Status of Adults With Systemic Sclerosis. Case-Control Study, J Periodontol, 2011; **82**: 1140–1145.
37 Wood RE, Lee P. Analysis of the oral manifestations of systemic sclerosis (scleroderma). *Oral Surg Oral Med Oral Pathol* 1988; **65**: 172–178.
38 Yuen HK, Weng Y, Bandyopadhyay D, Reed SG, Leite RS, Silver RM. Effect of a multi-faceted intervention on gingival health among adults with systemic sclerosis. *Clin Exp Rheumatol* 2011; **29** (2 Suppl. 65): S26–S32.
39 Felder R, James K, Brown C, Lemon S, Reveal M. Dexterity testing as a predictor of oral care ability. *J Am Geriatr Soc* 1994; **42**: 1081–1086.
40 Felder R, Reveal M, Lemon S, Brown C. Testing toothbrushing ability of elderly patients. *Spec Care Dentist* 1994; **14**: 153–157.
41 Hill EG, Slate EH, Wiegand RE, Grossi SG, Salinas CF. Study design for calibration of clinical examiners measuring periodontal parameters. *J Periodontol* 2006; **77**: 1129–1141.
42 Loe H, Silness J. Periodontal Disease in Pregnancy. I. Prevalence and Severity. *Acta Odontol Scand* 1963; **21**: 533–551.
43 Podshadley AG, Haley JV. A method for evaluating oral hygiene performance. *Public Health Rep* 1968; **83**: 259–264.
44 Naylor WP, Douglass CW, Mix E. The nonsurgical treatment of microstomia in scleroderma: a pilot study. *Oral Surg Oral Med Oral Pathol* 1984; **57**: 508–511.
45 Wood GD, Branco JA. A comparison of three methods of measuring maximal opening of the mouth. *J Oral Surg* 1979; **37**: 175–177.
46 Fox PC, Busch KA, Baum BJ. Subjective reports of xerostomia and objective measures of salivary gland performance. *J Am Dent Assoc* 1987; **115**: 581–584.
47 Maddali Bongi S, Del Rosso A, Galluccio F *et al*. Efficacy of a tailored rehabilitation program for systemic sclerosis. *Clin Exp Rheumatol* 2009; **27** (3 Suppl. 54): 44–50.
48 Mugii N, Hasegawa M, Matsushita T *et al*. The efficacy of self-administered stretching for finger joint motion in Japanese patients with systemic sclerosis. *J Rheumatol* 2006; **33**: 1586–1592.
49 Lyle DM. Use of a water flosser for interdental cleaning. *Compend Contin Educ Dent* 2011;**32**: 78, 80–82.
50 Albert-Kiszely A, Pjetursson BE, Salvi GE *et al*. Comparison of the effects of cetylpyridinium chloride with an essential oil mouth rinse on dental plaque and gingivitis - a six-month randomized controlled clinical trial. *J Clin Periodontol* 2007; **34**: 658–667.
51 Schroeder PL, Filler SJ, Ramirez B, Lazarchik DA, Vaezi MF, Richter JE. Dental erosion and acid reflux disease. *Ann Intern Med* 1995; **122**: 809–815.