Prevalence of Non-carious Cervical Lesions and Associated Risk Indicators in Middle-aged and Elderly Populations in Southern China

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Objective: *To explore the prevalence of NCCL and associated risk indicators in 35- to 44-year-olds and 65- to 74-year-olds from both urban and suburban districts of Guangzhou, Southern China.*

Methods: *A cross-sectional survey was conducted on NCCL with a sample of 768 35- to 44-year-olds and 991 65- to 74-year-olds, and the Tooth wear index was applied to record the tooth wear. Data on socioeconomic status, health behaviour and general health condition were obtained from a structured questionnaire.*

Results: *The prevalence of NCCL was 76.8% and 81.3% in middle-aged and elderly populations, respectively. The results from the analysis of covariance (ANCOVA) demonstrated that for the 35- to 44-year-olds, those who were male, older, living in the suburban district and used toothpicks frequently, they tended to have more teeth with NCCL. Men, who were aged between 65 and 74 years old, who used toothpicks frequently, drank vinegar beverages, ate hard food and had not visited a dentist in a year; tended to have more teeth with NCCL.*

Conclusion: *NCCL was very common amongst middle-aged and elderly populations in South China. Older men who had unhealthy oral habits like using toothpicks, eating hard food and drinking vinegar beverages tended to have more teeth with NCCL. Oral health education would benefit those at risk.*

Key words: *non-carious cervical lesions, prevalence, risk indicator*

Non-carious cervical lesions (NCCL) result from the loss of hard tissue on the cementoenamel junction of tooth which has no relationship with bacteria[1]. The shapes of the lesion usually are wedge-shaped, flattened, disk-shaped and irregular[2].

The origin of NCCL is contentious and it is thought to be related to the combination of erosion, abrasion and stress[3]. The erosion might cause loss of tooth surface through chemical or electrochemical effect, which includes intrinsic and extrinsic acid. Intrinsic acid usually comes from the stomach and is associated with eating disorders. Several researchers reported that erosion was related to gastroesophageal reflux disease (GORD)[4,5]. Extrinsic acid usually originates from food, beverages and the work environment, such as carbonated soft drinks, fruit juice, wine and vinegar[6-8]. Abrasion is associated with overzealous toothbrushing; the improper use of dental floss and toothpicks; and biting hard objects such as pens or pencils[3]. A clinical study suggested that horizontal brushing caused two or three times as much wear compared with vertical brushing. A further study reported that wear, to some extent, depended on the force and frequency applied to the brush[9]. Stress concentration on the tooth surface may result in flexure and failure of enamel and dentin. Rees et al[10] and Borcic et al[11] found that occlusal inter-

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ferences, premature contacts, habits of bruxism and clenching all may produce high load forces. When the stress concentrates on the cervical region through the axial and lateral load, it might lead to stress, fatigue and fragility of tooth tissue. Although a lot of studies suggested NCCL is a multifactor disease, the aetiology of NCCL remains unclear. Even without the attack from bacterium, NCCL can cause pain, aesthetic limitations and in extreme cases, tooth fractures. Better understanding of the aetiology of NCCL will be helpful to prevent its occurrence.

It was reported that the prevalence of NCCL varied from 5% to 85%[12-16]. With the rapid economic development in China, more dental disorders have begun to receive greater attention. However, the information on NCCL is scarce. The aim of this study was to describe the prevalence of NCCL in 35- to 44- and 65- to 74-year-olds amongst the Chinese population, from both urban and suburban districts in Guangzhou, Southern China; and to explore the associated risk indicators of the lesions.

Material and methods

Sample

Guangzhou, the capital city of Guangdong Province, is one of the most developed cities in Southern China. It is comprised of 10 urban districts and two suburban districts; and has a population of about 10 million people. The gross domestic product (GDP) per capita was 72,123 RMB in 2007[17].

A cross-sectional study was conducted in Guangzhou in 2008 by stratified multi-stage sampling. The estimated prevalence was set at 38.8% and 56.6% in the two age groups, respectively. This was based on the reported prevalence of wedge-shaped defects in the Hubei province in central China[18]. The smallest sample size was 380 in the middle-aged group and 393 in the elderly group calculated using the sample size formula ($\mu\alpha = 2$, $d = 0.05$).

During the first stage of sampling, three out of 10 urban districts in Guangzhou were selected, based on their characteristics, in order to achieve better representation. Yuexiu District is the traditional political centre of Guangzhou, Tianhe District is the business centre of Guangzhou and Baiyun District is an industry area with many factories. Two suburban districts were both included. At the second stage, two communities were randomly selected in each urban and suburban district. At the last stage, 70 to 80 subjects aged between 35 to 44 years old and 90 to 100 subjects aged between 65 to 74 years old were recruited by quota sampling in each community. In urban areas, the middle-aged subjects were examined at their place of work. The places of work and the proposed sample sizes of each type of occupation were selected according to the classification of occupation in China and its population ratio in Guangzhou[19]. The elderly subjects in the urban areas were recruited and examined in the communities they lived. In the suburban areas, all subjects were recruited and examined in the villages. A total of 1759 Chinese adults, made up of 768 35- to 44-year-olds and 991 65- to 74-year-olds participated in the study. A consent form was collected from the subjects before the examination and the protocol of the present study was in accordance with the Declaration of Helsinki.

Clinical examination

NCCL and the present restoration of cervical lesions were examined by a trained examiner (ZYL). The subjects were examined in the community with a portable dental chair, an intra-oral LED light source, dental mirrors and periodontal probes with millimeter marks. NCCL was diagnosed when the loss of contour was obvious at the cervical surface including buccal and lingual surfaces with the defects of V-shaped, wedge-shaped, or disc-shaped and free of caries[20]. Tooth wear index (TWI) was used to record the tooth wear in the cervical region, occlusal surface or incisal surface[21], which was classified into five degrees (0 to 5) (Table 1). When a tooth is diagnosed as NCCL, the TWI of the cervical surface was recorded as ≥ 222. Existed restoration was needed when the defect depth was not less than 1 mm (TWI ≥ 3)[22]. Occlusal attrition was recorded using TWI as well. The restoration of the cervical lesion was recorded regardless of the reason for restoration. The duplication was conducted on 10% of the subjects throughout the study to test the examiner's intraexaminer reproducibility.

Questionnaire

Each participant was asked to complete a structured questionnaire independently, prior to the clinical examination. Those who could not complete the questionnaire due to ill health or because they were from a low educational background were interviewed by trained interviewers.

The questionnaire was designed according to the study model reported by Grippo[3] in 2004, which included information about the socioeconomic status, oral health habits, eating habits, the frequency of drink-

Table 1 Copy of Smith and Knight tooth wear index.

Score	Surface	Criterion
0	B/L/O/I/C	No loss of surface characteristics
		No loss of contour
1	B/L/O/I/C	Loss of enamel surface characteristics
		Minimal loss of contour
2	B/L/O	Loss of enamel exposing dentine for less than one third of the surface
	I	Loss of enamel just exposing dentine
	C	Defect less than 1 mm deep
3	B/L/O	Loss of enamel exposing dentine for more than one third of surface
	I	Loss of enamel and substantial loss of dentine not exposing secondary dentine or pulp
	C	Defect 1 to 2 mm deep
4	B/L/O	Complete loss of enamel or pulp exposure or exposure of secondary dentine
	I	Pulp exposure or exposure of secondary dentine
	C	Defect more than 2 mm deep or pulp exposure or exposure of secondary dentine

Note: B - buccal or labial; L - lingual or palatal; O - occlusal; I - incisal; C - cervical

ing different beverages and recurrence of gastric acid conditions. Based on the study model, 20 independent variables were collected in the present study: age, gender, location of residence, marriage, education level, monthly income, occupation, frequency of brushing, use of toothpicks, method of tooth brushing, use of dental floss, bruxism, chewing on one side, biting hard objects, frequency of eating fruit, drinking carbohydrate and vinegar beverages, the recurrence of gastric acid, experience of visiting dentists and xerostomia.

Statistical analysis

The data was analysed with SPSS software (version 13.0). Intraexaminer reproducibility was evaluated by Cohen's kappa coefficient. Student's *t* test or analysis of variance (ANOVA) was used to analyse the relationship between the number of affected teeth and the categorical independent variables. Pearson's correlation coefficients were used for the continuous independent variables. Variables where $P < 0.2$ according to bivariate analysis were chosen as the independent variables for analysis of covariance (ANCOVA). The level of statistical significance was set at 0.05.

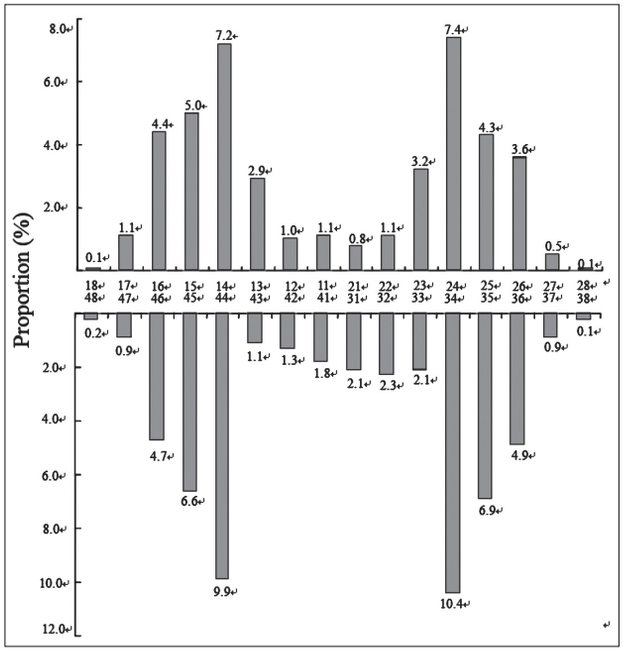

Fig 1 The distribution of NCCL in 35- to 44–year-olds.

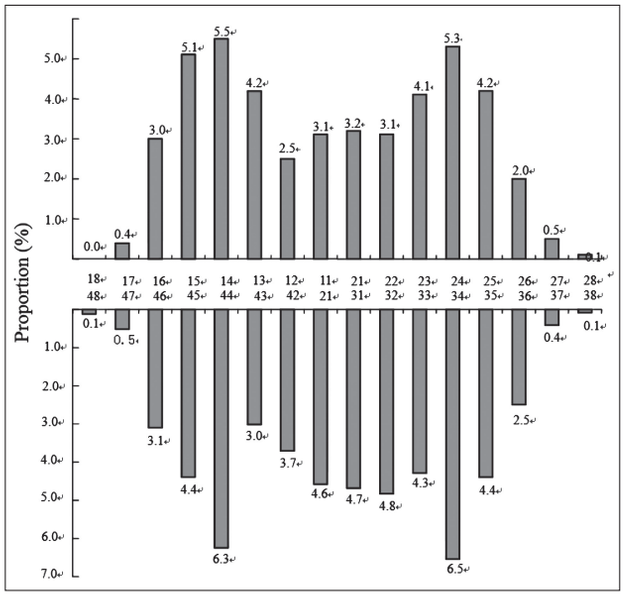

Fig 2 The distribution of NCCL in 65- to 74-year-olds.

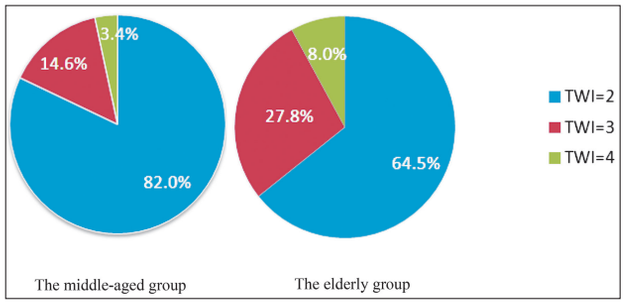

Fig 3 The severity of NCCL in both age groups.

Results

Clinical data

In total, 1759 subjects were examined, including 768 participants in the middle-aged group and 991 participants in the elderly group.

The mean number of teeth was 28.1 in the middle-aged group and 16.8 in the elderly group. The prevalence of NCCL was 76.8% and 81.3%, with a mean of 3.4 and 4.4 teeth affected amongst the two age groups, respectively. 26.3% of the middle-aged and 49.0% of the elderly subjects examined had at least one tooth with NCCL $\geq$ 1 mm, which needed restoration. The mean number of restorations presented on the cervical regions was 0.1 and 0.8 for the middle-aged and the elderly groups, respectively. Each participant in the middle-aged group had more than one tooth, while 5.5% of the elderly were edentulous. If the edentulous subjects were eliminated, the prevalence of NCCL was 86.1% for the elderly group and 51.9% of the elderly needed restorations due to NCCL. The edentulous subjects were excluded in the statistical analysis involving associated risk indicators of NCCL.

As shown in Fig 1 and Fig 2, the distribution of NCCL was almost bilaterally symmetrical. The most frequently affected teeth were the first premolar, followed by the second premolar and the first molar in the middle-aged group. For the elderly group, the most frequently affected teeth were also the first premolar, followed by the second premolar and the canine.

In the present study, we used the tooth wear index to record the severity of affected teeth. The most significative indexes are 2, 3 and 4, which represent well-informed cervical lesions. It was shown that more elderly people had stage 3 NCCL than middle-aged people (27.8% vs 14.6%). Stage 2 was the most common and stage 4 was rare in both age groups (see Fig 3).

The value of Cohen's kappa coefficient for the duplicated examination of NCCL was 0.99, which indicated excellent intraexaminer reproducibility.

Questionnaire data/associated risk indicators

Only the dentate subjects were included in the analysis of associated risk factors. The relationships between demographic information and NCCL in the two groups are shown in Table 2. The findings indicate that in the middle-aged group, men and suburban residents had more affected teeth. In the elderly group; gender, marriage status, education level, monthly income and occupation before retirement were factors which demonstrated a significant relationship with NCCL. As age is a continuous variable, the correlation coefficient between age and NCCL was analysed. The Pearson correlation coefficient between age and NCCL were 0.151 ($P < 0.001$) and 0.125 ($P < 0.05$) for the middle-aged and the elderly groups, respectively.

The relationship between oral health habits and NCCL are shown in Table 3. In both age groups, people who used toothpicks frequently had more affected teeth. In the middle-aged group, people who brushed teeth horizontally had more affected teeth. In the elderly group, subjects with bruxism and a habit of biting hard objects had more affected teeth.

It was shown that eating fruit, drinking carbohydrate and vinegar beverages had no relationship with NCCL in the middle-aged group (Table 3). Whilst in the elderly group, subjects who ate fruit and drank vinegar

Table 2 The relationship between demographic information and NCCL in the two age groups.

Variables	35- to 44-year-olds			65- to 74-year-olds		
	N	Affected teeth (SE)	*P*	n	Affected teeth (SE)	*P*
Location of residence						
Urban	452	2.9(3.4)		568	4.7(4.0)	
Suburban	316	4.2(4.2)	< 0.001	368	4.4(4.0)	0.266
Gender						
Male	396	3.8(4.0)		455	5.6(4.3)	
Female	372	3.0(3.5)	0.007	481	3.7(3.4)	< 0.001
Marriage						
With spouse	735	3.4(3.8)		696	4.9(4.1)	
Without spouse	33	2.9(3.1)	0.385	240	3.8(3.5)	0.001
Education level						
No schooling	164	3.7(3.2)		613	4.2(3.8)	
Primary	272	3.3(3.6)		122	5.6(4.3)	
Secondary and above	332	3.4(3.8)	0.520	201	5.2(4.2)	< 0.001
Monthly income per capita						
< RMB 1000	340	3.7(4.2)		460	4.2(4.0)	
RMB 1000–1999	192	3.3(3.7)		186	4.7(3.7)	
≥ RMB 2000	236	3.1(3.3)	0.096	290	5.1(4.2)	0.023
Occupation						
Professional/employer	137	3.0(3.2)		210	5.1(4.3)	
Non-professional/employee	465	3.4(3.9)		278	5.0(3.9)	
Farmer	166	3.9(3.9)	0.103	448	4.1(3.9)	0.003

beverages once or more than once per week had more affected teeth.

Bivariate analysis showed that there were no significant relationships between the number of teeth affected by NCCL and gastric acid recurrence ($P > 0.05$), the experience of visiting the dentist and xerostomia in both age groups.

The results of ANCOVA analysis are shown in Table 4 and Table 5 for the two age groups. In the middle-aged group, those who were male, older, living in the suburban district and used toothpicks frequently, had more affected teeth. In the elderly group, men who used toothpicks frequently, drank vinegar beverages once or more than once per week, had a habit of biting hard objects and had no experience of visiting a dentist in the latest 12 months, had more affected teeth.

Discussion

Stratified quota sampling was used in the study instead of random sampling due to the characteristics of the study. At the first stage of sampling, three districts in Guangzhou were chosen based on their characteristics. One district represents the centre of culture and administration, one represents the financial centre and the other represents the centre of industry. Random sampling is the standard sampling method in a survey which ensures the sample to be representative when the sample size is large enough. However, selection of the three representative districts in Guangzhou would be more appropriate in the study since random sampling may not ensure the diversity and balance of the population. At the last stage of sampling, quota sampling was used because random sampling was

Table 3 The oral health habits and eating habits related to NCCL in the two age groups.

Variables	35- to 44-year-olds			65- to 74-year-olds		
	N	Affected teeth (SE)	*P*	n	Affected teeth (SE)	*P*
Frequency of brushing						
≤ Once a day	394	3.6(4.0)		486	4.5(3.9)	
> Once a day	374	3.3(3.6)	0.300	450	4.7(4.1)	0.313
Use of toothpick						
Never/occasional	319	2.6(3.2)		349	3.6(3.7)	
Once a day	88	3.2(3.9)		51	4.8(4.0)	
> Once a day	361	4.2(4.2)	< 0.001	536	5.2(4.1)	< 0.001
Method of brushing						
Horizontal	364	3.9(4.2)		536	4.6(4.0)	
Vertical	404	3.0(3.4)	< 0.001	400	4.7(4.0)	0.691
Use of dental floss						
No	746	3.4(3.8)		923	4.6(4.0)	
Yes	22	2.7(3.6)	0.362	13	5.5(5.3)	0.398
Bruxism						
No	674	3.5(3.9)		878	4.5(4.0)	
Yes	94	3.4(3.8)	0.906	58	5.8(3.8)	0.022
Chewing on one side						
No	324	3.4(4.0)		440	4.6(4.0)	
Yes	444	3.4(3.6)	0.957	496	4.6(4.0)	0.949
Bite hard objects						
No	572	3.3(3.8)		743	4.3(3.8)	
Yes	196	3.7(4.0)	0.210	193	5.5(4.6)	0.001
Eating fruit						
< Once a week	244	3.7(3.8)		421	4.2(3.9)	
≥ Once a week	524	3.3(3.8)	0.223	515	4.9(4.1)	0.009
Drinking carbohydrate beverage						
< Once a week	605	3.6(3.9)		893	4.6(4.0)	
≥ Once a week	163	2.9(3.3)	0.053	43	4.4(3.4)	0.756
Drinking vinegar beverages						
< Once a week	669	3.5(3.9)		854	4.5(3.9)	
≥ Once a week	99	2.9(3.3)	0.075	82	5.7(5.0)	0.008
The experience of visiting a dentist in the last 12 months						
No	575	3.5(3.8)		728	4.7(4.1)	
Yes	193	3.1(4.0)	0.151	208	4.1(3.6)	0.058

Table 4 Relationship between NCCL and selected independent variables amongst the 35- to 44-year-olds (results of ANCOVA analysis).

Independent variable	Estimate	SE	*P*	Bonferroni's multiple comparison
Location of residence				
Urban			< 0.001	
Suburban	-1.511	0.403		
Gender				
Male			0.016	
Female	0.645	0.268		
Use of toothpick				
Never/ occasional(1)			< 0.001	(3) > (1)
Once a day (2)	-1.074	0.302		
> Once a day(3)	-0.301	0.462		
Age	0.140	0.042	0.001	

F = 5.822; df (degrees of freedom) = 12, 755; $P < 0.001$

Table 5 Relationship between NCCL and selected independents variables amongst the 65- to 74-year-olds (results of ANCOVA analysis).

Independent variable	Estimate	SE	*P*	Bonferroni's multiple comparison
Gender				
Male			< 0.001	
Female	1.587	0.265		
Use of toothpick				
Never / occasional (1)			< 0.001	(3) > (1)
Once a day (2)	-1.320	0.266		
> Once a day(3)	-0.276	0.558		
Drink vinegar beverages				
< Once a week			0.040	
≥ Once a week	-0.955	0.465		
Bite hard objects				
Yes			0.032	
No	0.688	0.321		
Experience of visiting a dentist within a year				
No			0.004	
Yes	0.911	0.316		
Age	0.077	0.039	< 0.001	

F = 7.437; df =18, 917; $P < 0.001$

too difficult to carry out. For both age groups in the suburban districts and the elderly subjects in the city, it was assumed that there is little difference between the subjects in the same community. Furthermore for the middle-aged group in the city, the subjects were recruited according to the proposed sample size of each kind of occupation, in order to decrease sampling bias.

It was reported that the prevalence of cervical wear varied from 5% to 85%[12-16]. The variation of prevalence may be influenced by socioeconomic, cultural and geographic factors. The prevalence of NCCL in Guangzhou was 76.8% and 81.3% in the middle-aged group and the elderly group, respectively, in the present study, and it was similar to findings reported by Oginni on a Nigerian population[14]. Some researchers found that the first premolar was at the highest risk of developing NCCL[15,23-26];a similar trend was found in the present study. The most frequently affected teeth were the first premolar, followed by the second premolar and the first molar in the middle-aged group. In the elderly group, the most frequently affected teeth were also the first premolar, followed by the second premolar and the canine. However, one study indicated that the most frequently affected teeth were the first lower molar, followed by the first upper molar and the first upper premolar amongst 16- to 24-year-olds[23]. All studies showed that the posterior teeth were more likely to exhibit NCCL, possibly due to the fact that greater occlusal forces and more lateral forces are exerted in the posterior teeth[13]. Aside from this, it might be associated with the natural anatomical morphology of the teeth, the natural progressive development of group function from anterior to posterior; periodontium and vestibule[23,27,28].

The relationship between NCCL and the variables under study were investigated with bivariate and multivariate analysis. The results of ANCOVA analysis showed that age, gender, location of residence and the use of toothpicks were risk indicators for NCCL in 35- to 44- year-olds in South China. Whilst the results of ANCOVA analysis in 65- to 74-year-olds demonstrated that age, gender, the use of toothpicks, drinking vinegar beverage, biting hard objects and the experience of visiting a dentist in the last 12 months were related to NCCL.

In the present study, the prevalence of NCCL increased with increasing age for both age groups, which was similar to most studies[15,25,26]. It might be because the teeth have been exposed to the aetiological factors for a longer time and are sometimes coupled with marginal tissue or gingival recession, so older people are at greater risk of NCCL[16]. In addition, older persons are more likely to have fewer teeth to bear the occlusal load, with a loss of the protective mechanisms of natural dentition and due to the diminished quantity and quality of saliva. Furthermore, the composition and microstructure of enamel and dentin changed with the ageing process, which might also lead to lesion formation.

In the present study, we found that men had more affected teeth than women in both groups, which is in agreement with the results of two surveys[25,29]. In 1965, Manly et al reported that wear is, to some extent, dependent upon the force and frequency applied to the brush[30]. Males might apply greater force during brushing and have more NCCL than females. However, there are some studies which showed that there was no relationship between gender and the prevalence of NCCL[13,26]. The force of brushing may also vary with the brushing techniques, the groups of teeth brushed, the stiffness of the bristles, the age of the brusher and individual brushing habits, as indicated by some laboratory studies[31-33]. So the relationship between gender and NCCL may not be absolute.

It was found that suburban residents had more NCCL than urban residents in the middle-aged group for this study. The mean number of affected teeth was 4.2 for suburban residents and 2.9 for urban residents. The suburban residents, recruited from villages, might lack oral health education and have unhealthy oral habits such as incorrect tooth brushing method, which might lead to NCCL. Prevention methods of NCCL are needed more urgently in rural areas.

The findings indicated that people who used toothpicks had a higher risk to NCCL for both groups in the present study. Few researchers reported that this habit related to NCCL in other countries. The prevalence of using toothpicks among adults varies from 20.7% to 75.0% in China[34-36], which was higher than the Western countries. A review indicated that abrasion can occur as a result of improper use of toothpicks[3]. According to some reports, habitual idiopathic, palliative or therapeutic use of a toothpick may form interproximal grooves which are located at or near the cervical margin, on mesial and/or distal approximal surfaces[37-39]. When involved in buccal surfaces, it might result in NCCL. The improper use of toothpicks may be considered as a risk factor for NCCL. However, due to its accessibility, this makes toothpicks the most popular interdental cleaning tool in China. Therefore the proper use of toothpicks should be emphasised in oral health education; and the use of other interproximal devices such as the interdental brush and dental floss need to be introduced.

In the elderly group, the study revealed that subjects who drank vinegar beverages once or more than once a

week had more teeth affected than those that drank less. Several studies reported that vinegar and vinegar beverages have a relationship with erosion[40-42]. However, few researchers supported the notion that vinegar was related to NCCL. The pH range of vinegar is between 2.400 and 3.443; and it has a strong corrosive action, which might dissolve the dental hard tissue and cause dental erosion. When it occurred on the cervical region, it may have accelerated this form of NCCL.

The findings indicate that elderly people who bite hard objects had a higher risk to NCCL. Several studies showed that occlusal load was associated with NCCL[11,20,29,44]. Biting hard objects could produce large occlusal loading forces and cause heavy stress on the cervical region, which is prone to lead to the collapse of dental enamel. An experimental study confirmed that under the abnormal occlusion, the pressure on the cervical region increased to -501.947 ~ +82.4 Mpa, while under normal occlusion the pressure was only -259 ~ + 2.25 Mpa[11]. As the tooth flexes, tensile and shear stresses are generated in the cervical region of the tooth that causes disruption of the bonds between the hydroxyapatite crystals, leading to crack formation and eventually the loss of enamel and the underlying dentine[45].

In the present study, it was also found that people who visited the dentist in the last 12 months had a lower risk of NCCL. Since NCCL is a multi-factor disease, the state of oral health is expected to affect its formation. Visiting a dentist could lead to the restoration of the lesions. Dentists could also help the patients prevent further development of NCCL. Oral health instructions from dentists would be an effective method to prevent NCCL.

It was found that 26.3% of the middle-aged and 49.0% of the elderly subjects examined had at least one tooth with NCCL $\geq$ 1 mm, which needed restoration. The morbidity of NCCL was pretty high in both the middle-aged and the elderly groups in South China. NCCL can seriously affect a person's quality of life based on oral health. The corresponding need of dental treatment would make the present condition of insufficiency of dental resources more severe. Therefore targeted intervention to prevent NCCL could benefit not only the susceptible population, but also the whole population. The risk indicators found in the present study would be helpful to find specific target populations and then oral health instructions could be subsequently launched.

A limitation of the study was that the result might be influenced by the restorations on the cervical regions since the reason of the restorations could not be differentiated during the examination. The mean number of teeth affected by NCCL was 3.4 and the restorations on the cervical regions was 0.1 for the middle-aged people, so the effect on the results of the middle-aged group might be minor. The mean number of teeth affected by NCCL was 4.4 and the restoration on the cervical regions was 0.8 for the elderly group. Therefore, the mean number of teeth affected by NCCL in the elderly group could have been increased without the restorations.

Conclusions

Non-carious cervical lesions were common amongst middle-aged and elderly populations in South China, which might have a negative influence on their quality of life based on their oral health. This study indicated that the elderly men, living in suburban areas, using toothpicks frequently, biting hard objects and drinking vinegar beverages once a week had a higher risk of NCCL. Good oral habits might help to prevent the occurrence of NCCL in middle-aged and elderly people in South China.

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