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A 4-year prospective study of the progression of periodontal disease in a rural Chinese population

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ABSTRACT

Objectives: The natural progression of periodontitis in the Chinese population is not well researched. We investigated the progression of periodontal disease over 4 years in 15–44-year-old Chinese villagers with no access to regular dental care.
Methods: In 1992, 486 villagers were enrolled, and in 1996, 413 villagers were re-examined. Probing depth (PD) and clinical attachment level (CAL) were examined at six sites per tooth. Sites with ΔCAL $\geq$3 mm were defined as active sites. Cross-sectional and longitudinal analyses were performed using means and percentile plots.
Results: The mean CAL increased by 0.26 mm over 4 years. The incidence of periodontitis (at least one site with CAL $\geq$3 mm) was 8%. The incidence of periodontitis among those with no periodontal disease at baseline was 44.9%. Seventy-eight percent of the subjects had at least one active site. In the 15–24-year group, 244 of 401 active sites had gingival recession, while only 51 active sites had both gingival recession and deeper pockets. In the 25–34-year and 35–44-year groups, almost one-third of the active sites (329/1087) and more than one-third of the active sites (580/1312) respectively had a combination of gingival recession and deeper pockets.
Conclusions: In this study, we demonstrated that in Chinese population without regular dental care, both the initiation of periodontitis and progression of previously existed periodontitis contributed to the natural progression of periodontitis and periodontal pocketing played a greater role with age increasing.
Clinical significance: This rare study reports the natural progression of periodontal disease in a group of Chinese villagers (15–44 years) with virtually no access to regular dental care.

1. Introduction

Periodontal diseases are inflammatory diseases of periodontal supportive tissue that typically lead to alveolar bone loss and even tooth loss. It is currently a major cause of tooth loss among adults.[1,2] Periodontal diseases affect a considerable part of the population in developing as well as developed countries, but their prevalence rates vary significantly among populations from 24.5% to 79.6% (Brazilian,[3–5] Norwegian,[6,7] Sri Lankan,[6,8,9] North American,[10–16] Swedish,[10,17,18] Pomeranian,[19–21] Japanese,[22–25] Chinese,[26–30] Indonesian,[31] Australian[32,33]). These differences in the prevalence rate are related to various demographic, socioeconomic, and behavioural factors such

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as age, gender, ethnicity, level of income, smoking habits, and oral health habits. The effect of age on the progression of periodontal disease is controversial. Most studies show higher progression with increasing age,[3,31,34] while some studies did not find any differences between age groups and others even reported a decrease with increase in age.[25,35,36] Further, some studies found a lower progression rate in females than in males.[3,14,16,37] However, no gender-based differences have been found in other studies.[38] In addition, at a subject level, disparities have been reported in the progression rate between different teeth and sites.[27]

Most studies on periodontal diseases have been conducted on subjects who regularly visit the dentist and have good oral habits. Thus, the results of these studies are a combination of the result of natural disease progression and the influence of dental health care systems on the progression of periodontal disease. Because of the high level of awareness about oral health care, it is difficult to study the natural history of oral diseases as subjects with no dental health care are few. Only a few study groups[6,8–10,24–28,34,39–41] have reported the natural history of periodontal diseases progression in populations with limited dental health care.

In the Chinese population, only two studies[26–28,30] have been conducted on the natural history of progression in populations with limited dental health care. The first one is by Baelum et al.[27] who reported the natural history of periodontitis in Chinese villagers (20–80 years) during a 10-year period. Although the age spectrum was wide, teenagers who were less than 20 years old were not included. The second study was conducted over 1992–1996 by our study group among northern China villagers with virtually no access to regular dental care.[28,30] Young and middle-aged subjects (15–44 years) were enrolled, and the preliminary report of the first 2-year analysis was published.[26,30] The periodontal changes in children (9–14 years) over a 3-year period, from 1993 to 1996, have also been reported.[28] However, the results of the 4-year analysis have not been reported yet.

The purpose of this study is to describe the progression of periodontal diseases using the 4-year data in a 15–44-year-old population of Chinese villagers with limited dental health care.

2. Materials and methods

In 1992, a prospective study was carried out in Chengde village about 300 km north of Beijing, People's Republic of China. The total population of the village was 2124.[28] Oral hygiene practices are traditionally limited in this village. No more than half of the villagers possessed a toothbrush, and the closest dental clinic was almost 10 km away.

At baseline, 486 people (15–44 years, M = 211, F = 275) were enrolled using a stratified randomised sampling method and examined by one of four examiners. Two random quadrants, either the maxillary right and mandibular left or the maxillary left and mandibular right, were selected. The following periodontal assessments were made: modified bleeding index (MBI),[28] probing depth (PD) and clinical attachment level (CAL) at six sites per tooth (mesio-buccal, buccal, disto-buccal, mesio-lingual, lingual and disto-lingual), and the Tureskey modified Quigley-Hein plaque index (PLI) and calculus index (CI) at two surfaces of the tooth (buccal and lingual). The method for determining MBI is described in detail by Suda.[28] The percentage of sites that bled on probing (BOP%) was calculated per subject. If CAL was greater than PD, then gingival recession (RE) was calculated by subtracting PD from CAL. Otherwise, it was assumed that there was no recession. In 1996, 413 subjects were re-examined by the same examiners who had performed the initial examination. The examiner who conducted the baseline examination for an individual also conducted the re-examination for that individual. Calibration was performed during each examination year. Inter- and intra-examiner agreement was excellent (the reliability coefficient was over 0.9).

For comparison of the cross-sectional data in 1992 and 1996, analyses were performed using means and percentile plots.[24,25] In a percentile plot, the x-axis indicated the cumulative% of persons with CAL $\geq$threshold, and the y-axis indicated the % of sites/person with CAL $\geq$threshold. From the plot, we could see both the prevalence reflected by the x-axis and the corresponding extent (% of sites/person), which was reflected by the y-axis. We also analysed the longitudinal data of subjects ($N = 413$) enrolled in both examinations. The sites with ΔCAL $\geq$3 mm were defined as periodontal disease activity sites. Statistical analyses were conducted using the Independent-Sample T test and the χ^2 test.

3. Results

3.1. Cross-sectional analysis

3.1.1. Periodontal parameters

The mean values of the periodontal parameters are presented in Table 1. These values indicate the 4-year differences in the

Table 1 – Mean values obtained in the two examinations conducted over the 4-year study period.

Periodontal parameters	1992 ($n = 486$) Mean ± SD	1996 ($n = 413$) Mean ± SD	Annual change	P-value*
Clinical attachment level (mm)	1.57 ± 1.14	1.83 ± 1.38	0.065	<0.01
Probing depth (mm)	2.33 ± 0.55	2.63 ± 0.56	0.075	<0.01
Gingival recession (mm)	0.17 ± 0.24	0.32 ± 0.52	0.038	<0.01
% sites with BOP (+)	37.0 ± 22.5	41.3 ± 28.2	1.075	0.01
Plaque index	3.50 ± 0.47	3.59 ± 0.60	0.023	0.01
Calculus Index	2.22 ± 0.71	2.26 ± 0.73	0.010	0.43

BOP: bleeding on probing.
* Independent-Sample T test.

results of the two examinations. The mean CAL increased significantly by 0.26 mm ($P < 0.01$); the mean PD increased by 0.30 mm ($P < 0.01$); and the mean RE increased by 0.15 mm ($P < 0.01$). The BOP rate increased by 4% ($P < 0.05$). The mean PLI and CI increased during the 4-year period, but only PLI increased significantly ($P < 0.01$). In 1992, none of the subjects had tooth loss, but in 1996, the mean tooth loss was 0.5 teeth/person.

3.1.2. *CAL*

The percentile plots depicted the cumulative frequency distribution of individuals according to the % of sites/person with CAL ≥threshold at baseline (1992) (Fig. 1A) and 4 years later (1996) (Fig. 1B). The percentile plots indicated that with the decrease in the threshold, the prevalence rate and the % of sites/person with CAL ≥threshold increased accordingly. On

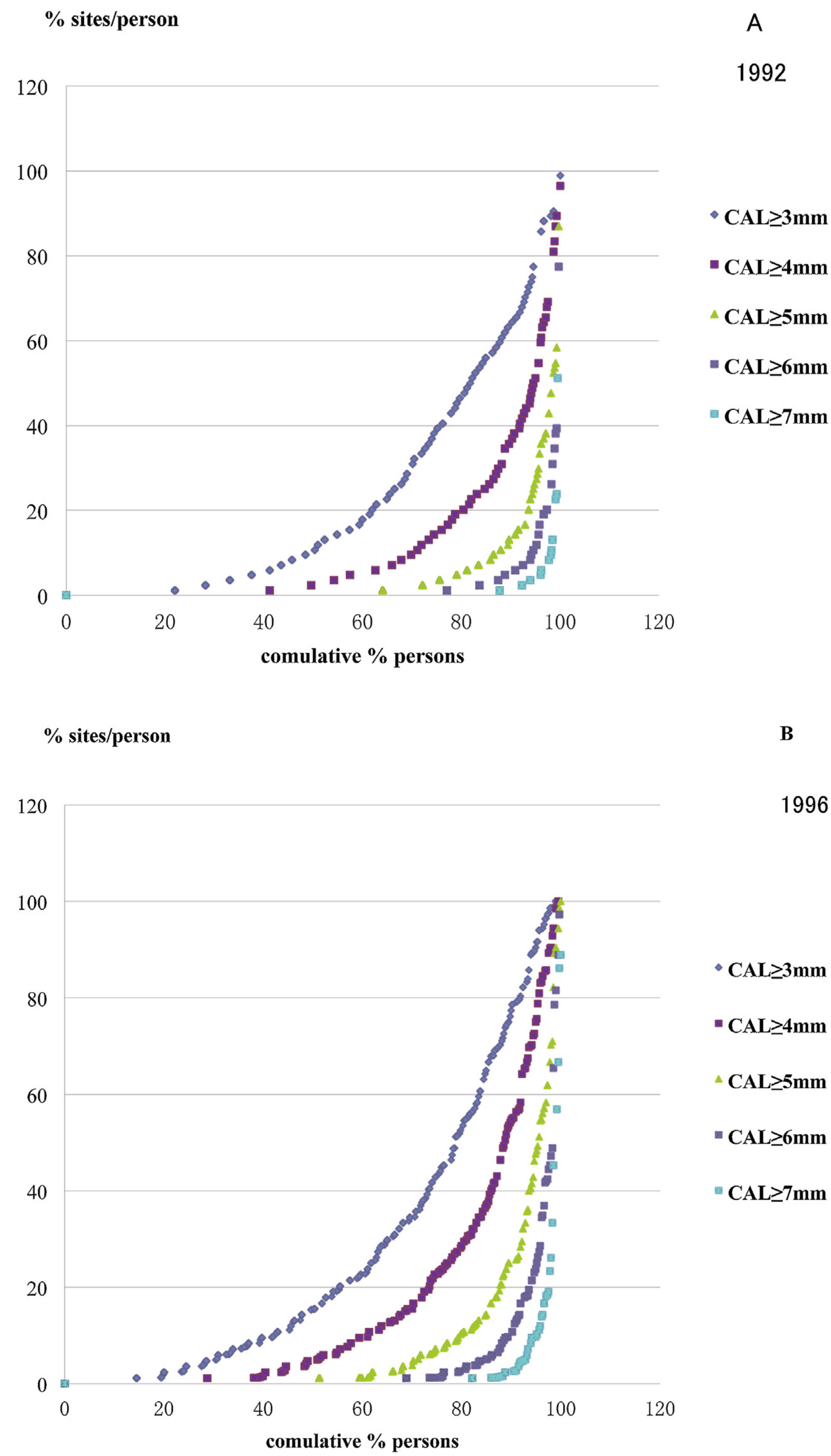

Fig. 1 – Comulative frequency distribution of individuals according to the proportion of sites/person with (A) CAL ≥threshold in 1992; (B) CAL ≥threshold in 1996.

Table 2 – Prevalence and extent rate of ΔCAL ≥3 mm.

Age group	Male		Female		Total	
	N	(Prevalence, extent)	N	(Prevalence, extent)	N	(Prevalence, extent)
15–24 yr	56	(65%, 4.1%)	97	(46%, 4.7%)[‡]	153	(52%, 4.5%)
25–34 yr	66	(73%, 11%)[*]	72	(74%, 9.3%)[*]	138	(73%, 10%)[*]
35–44 yr	59	(88%, 17%)[*,†]	63	(79%, 14%)[*,†]	122	(83%, 16%)[*,†]
Total	181	(75%, 11%)	232	(64%, 7.8%)	413	(68%, 10%)

[*] Compared with the 15–25-y group using the χ^2 test ($P < 0.05$).
[†] Compared with the 25–34-y group using the χ^2 test ($P < 0.05$).
[‡] Compared with male group using χ^2 test ($P < 0.05$).

comparison of the data for 1996 and 1992, we found that in 1996, there were more individuals with CAL ≥threshold, and for a single individual, there were more sites with CAL ≥threshold. For example, in 1992, 78% of the population had at least one site with CAL ≥3 mm while in 1996, the percentage increased to 86% ($P < 0.05$). In 1992, 12% of the individuals had at least one site with CAL ≥7 mm, and in 1996, the percentage increased to 18% ($P < 0.05$).

3.1.3. *Incidence of periodontitis*

Periodontitis was defined as at least one site with CAL ≥3 mm. In 1992, there were 82 participants with no evidence of periodontitis in the 15–24-year age group and only 14 participants with no periodontitis in the 25–34-year age group. All individuals in the 35–44-year age group had periodontitis to some extent. The incidence of periodontitis among those with no periodontal disease at the baseline was 44.9% (48/107). Furthermore, in the 25–34-year age group, 71.4% (10/14) individuals developed periodontitis over the 4-year follow-up period.

3.2. *Longitudinal analysis*

3.2.1. *ΔCAL*

We found that 87% of the individuals had ΔCAL ≥2 mm and for some individuals, all the sites had CAL progression of 2 mm. Only 15% of the participants had ΔCAL ≥7 mm. The % of sites/person with ΔCAL ≥7 mm differed across individuals, with the highest rate being 45%. The sites with ΔCAL ≥3 mm were defined as sites with periodontal disease activity. We found that 68% of the subjects had at least one site with disease activity. On average, 10% sites/person had attachment loss of 3 mm.

3.2.2. *Association of age and gender with ΔCAL*

The sites with ΔCAL ≥3 mm were defined as sites with periodontal disease activity. The prevalence rate of active sites and the mean extent rate of active sites were calculated. As shown in Table 2, periodontal tissue breakdown became more prevalent and widespread as age increased ($P < 0.05$). Male participants experienced more rapid progression than female participants in the 15–24-year-old group ($P < 0.05$), but in the 25–34- and 35–44-year groups, the difference between male and female subjects was not significant ($P > 0.05$).

3.2.3. *Association of tooth types and site types with ΔCAL*

The prevalence of active sites on teeth differed according to the tooth type (Fig. 2A). In both the maxillary and mandibular area, the mandibular incisors and molars had the highest number of active sites (25–28%). The lowest prevalence rate was observed in the maxillary canines (12%). The order from highest to lowest prevalence was mandibular incisors, molars, mandibular canines, mandibular premolars, maxillary premolars, maxillary incisors and maxillary canines. The prevalence rates of active sites also differed according to site types (Fig. 2B). Lingual active sites were greater in number than buccal active sites. Moreover, proximal active sites were lower in number than central sites.

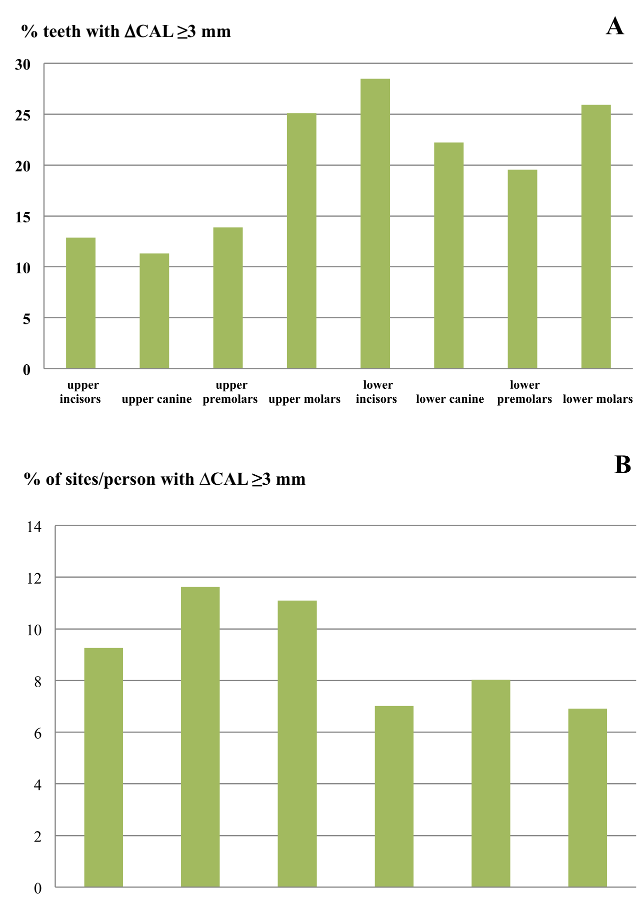

Fig. 2 – (A) Frequency distribution of teeth with active sites (ΔCAL ≥3 mm) and (B) frequency distribution of active sites.

3.2.4. Disease severity

Disease severity of the teeth with active sites is shown in Table 3. Severity was defined as the mean attachment loss of only active sites, not including the inactive sites. Over the four-year study period, the mean attachment loss of all the types of teeth with active sites was 3.55 mm. The attachment loss was associated with periodontal PD progression and recession progression. The mean periodontal PD progression of incisors with active sites was 1.37 mm, and the mean recession progression of incisors with active sites was 1.97 mm. The parameters of attachment loss differed according to tooth type. For example, the periodontal PD progression and recession progression were 1.37 mm and 1.97 mm respectively for the maxillary incisors, and 1.51 mm and 1.55 mm respectively for the molars. The disease severity of the active sites can be seen in Table 3. The mean attachment loss of the active sites was 3.91 mm over the 4-year study period. The parameters of attachment loss differed according to site type. For example, the periodontal PD progression and recession were 0.54 mm and 0.60 mm respectively for the central sites, and 2.09 mm and 0.33 mm respectively for the proximal sites.

3.2.5. Type of attachment loss

The attachment loss (ΔCAL) during the four years was characterised by increase in gingival recession and PD. In the 15–24-year group, 244 active sites were found to have gingival recession; 106 active sites were described as PD increase, and only 51 active sites were characterised by both gingival recession and increase in PD (Fig. 3A). In the 25–34-year group, one-third of the active sites (376) were characterised by increase in PD, and almost one-third of the active sites (329) were characterised by a combination of gingival recession and increase in PD (Fig. 3B). In the 35–44-year group, more than one-third of the active sites (580) were characterised by a combination of gingival recession and increase in PD, and 416 and 316 active sites were characterised by gingival recession and increase in PD respectively (Fig. 3C). With increase in age, more active sites with attachment loss caused by a combination of gingival recession and increase in PD were found. The Pearson chi-square test indicated that the ratio of active sites causing by combinition of recession and deeper pocket to all active sites was significantly different among different age groups.

Out of 1675 buccal active sites, 719 sites (43%) were characterised by gingival recession, while only 323 sites (29%) out of 1125 lingual active sites were characterised by gingival recession. Thus, a greater proportion of buccal active sites than lingual active sites were associated with gingival recession.

4. Discussion

Our study group conducted a 4-year research program (1992–1996) on natural periodontal disease progression in northern China villagers with virtually no access to regular dental care. The preliminary report of the first 2-year data analysis (1992–1994) and the next 3-year data analysis in children (1993–1996)

Table 3 – Mean progression of different teeth and sites with $\Delta CAL \geq 3$ mm.

Age group	Tooth types (*N*)	Mean ΔCAL	Mean ΔPD	Mean ΔRE
15–44 y	Incisors (802)	3.52 ± 1.23	1.37 ± 1.56	1.97 ± 1.41
	Molars (972)	3.56 ± 0.95	1.51 ± 1.72	1.55 ± 0.97
	Canines (331)	3.59 ± 1.06	1.31 ± 1.63	1.81 ± 1.22
	Premolars (686)	3.53 ± 0.99	1.44 ± 1.51	1.70 ± 1.02
15–24 y	Incisors (130)	3.20 ± 0.53	1.03 ± 1.56	1.45 ± 0.59
	Molars (153)	3.30 ± 0.97	0.94 ± 1.94	1.36 ± 1.03
	Canines (50)	3.33 ± 0.70	0.48 ± 1.62	1.48 ± 0.64
	Premolars (68)	3.23 ± 0.67	0.42 ± 1.52	1.62 ± 0.82
25–34 y	Incisors (296)	3.56 ± 1.45	1.50 ± 1.94	1.99 ± 1.67
	Molars (379)	3.54 ± 0.86	1.58 ± 1.70	1.57 ± 0.85
	Canines (146)	3.65 ± 1.12	1.53 ± 1.70	1.84 ± 1.28
	Premolars (266)	3.55 ± 1.02	1.45 ± 1.43	1.57 ± 1.03
35–44 y	Incisors (366)	3.69 ± 1.56	1.43 ± 1.49	2.16 ± 1.73
	Molars (450)	3.70 ± 0.96	1.72 ± 1.62	1.61 ± 0.96
	Canines (135)	3.58 ± 0.98	1.47 ± 1.51	1.84 ± 1.08
	Premolars (361)	3.60 ± 1.08	1.60 ± 1.31	1.82 ± 1.10
	Site types			
15–44 y	Mesial-lingual (481)	4.06 ± 1.96	2.11 ± 1.47	0.39 ± 1.47
	Central-lingual (604)	3.84 ± 1.90	0.50 ± 1.58	0.72 ± 1.26
	Distal-lingual (590)	3.90 ± 1.89	0.99 ± 1.66	0.49 ± 1.06
	Mesial-buccal (361)	3.93 ± 1.82	2.64 ± 1.53	0.20 ± 0.67
	Central-buccal (414)	3.78 ± 1.85	0.57 ± 1.68	0.48 ± 1.01
	Distal-buccal (350)	3.94 ± 1.82	2.60 ± 1.99	0.23 ± 0.78
	Proximal (1782)	3.96 ± 1.68	2.09 ± 1.80	0.33 ± 1.06
	Central (1018)	3.81 ± 1.28	0.54 ± 1.62	0.60 ± 1.16

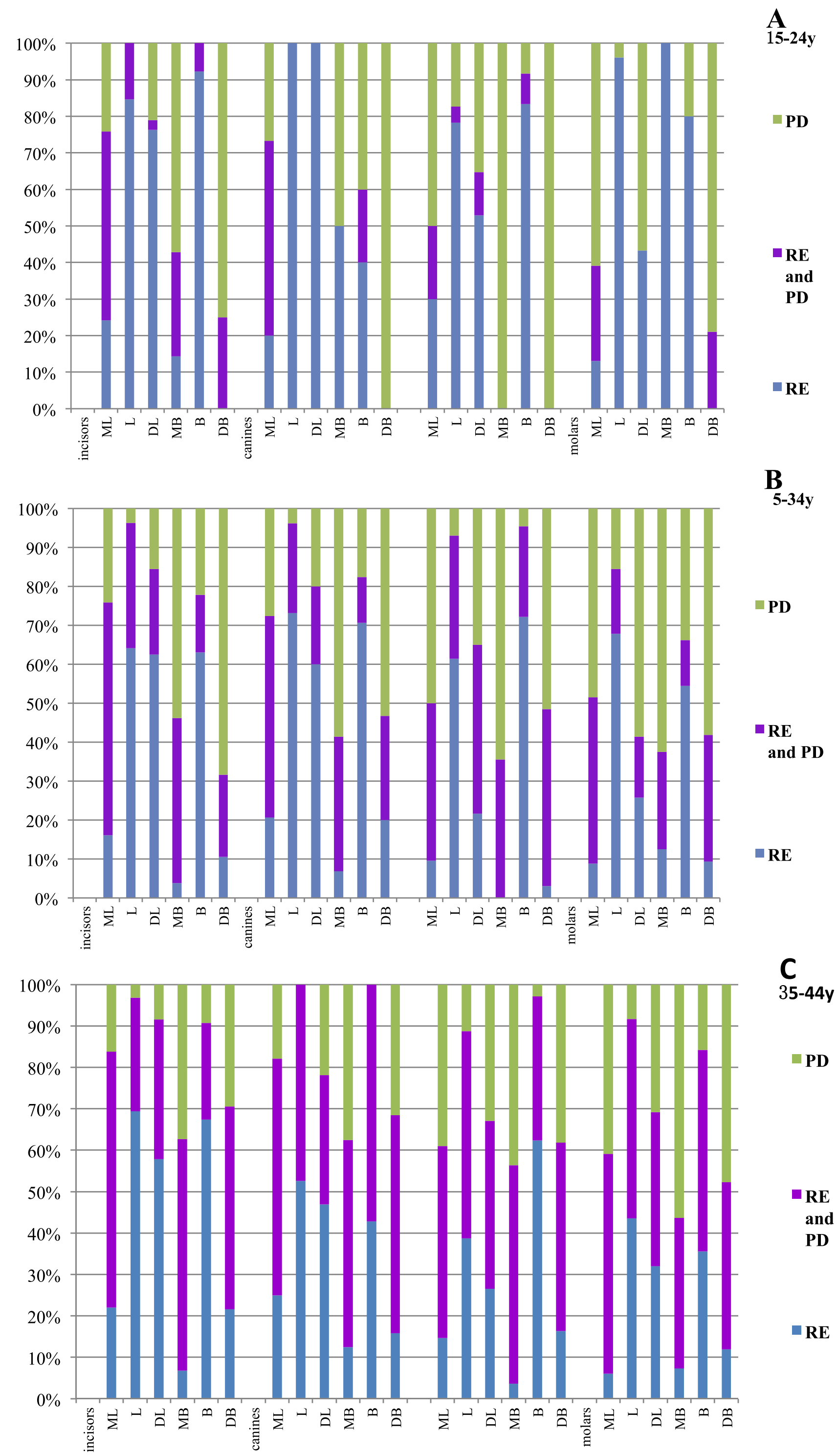

Fig. 3 – Proportion of sites with ΔCAL ≥3 mm with attachment loss in the form of recession, increase in probing depth or a combination of recession and increase in probing depth (A) in the 15–24 y; (B) in the 25–34 y; and (C) in the 35–44 groups.

have been published.[26,28] This research analysed the data using means and percentile plots to observe the natural progression of periodontal diseases over the entire 4-year study period (1992–1996).

The results of the present study show that Chinese villagers experience an average individual mean attachment loss of 0.26 mm over 4 years, which corresponds to 0.065 mm annually. The values appear to be lower than some of the values reported[6,25,27,42] but higher than some others.[17] For example, Ismail[11] reported the annual average attachment loss of subjects with dental visits in Michigan to be 0.04 mm over 28 years. Similarly, Löe et al.[6,43] reported that the mean annual rate of attachment loss was 0.05 mm over 26 years, and 0.08 mm for interproximal surfaces and 0.1 mm for buccal surfaces in Norwegians over 6 years. In contrast, the mean loss was reported[6] to be 0.20 mm per year for buccal surfaces and 0.30 mm for interproximal surfaces in Sri Lankans over a period of 7 years; however, this study only had male participants. Baelum[27] reported that adult and elderly Chinese with poor oral hygiene experienced an average mean 10-year attachment loss ranging between 0.15 mm and 0.19 mm annually. It is possible that our values were slightly lower because of the younger age group. Moreover, even though the average annual attachment loss reported by these studies is different, the difference was not considerable.

In the present study, we found that the prevalence of periodontal disease and the number of sites with periodontal disease in each subject increased over 4 years. When periodontitis was defined as at least one site with CAL $\geq$3 mm, the prevalence rate of periodontitis increased by 8% (from 78% to 86%) in 4 years. The incidence of periodontitis among those with no periodontal disease at baseline was 44.9% (48/107). To the best of our knowledge, this is the first report on the change in the prevalence rate of periodontitis over a longitudinal observation period at the population level. Person/teeth/site-level results are usually reported in longitudinal studies. Information about the changes in the disease prevalence rate in a population would be helpful to make a plan for taking action to prevent and control periodontitis. Since it is important for disease surveillance and prevention, changes in disease prevalence at the population level should be reported in longitudinal studies. This study thus makes an important contribution in this direction.

Disease progression (ΔCAL $\geq$3 mm) occurred in 68% of the subjects over the four-year period. On average, 10% of the sites per person had an attachment loss of 3 mm. In the present study, the progression rate of periodontal disease increased with age, which is consistent with the findings of most studies. Timmerman[31] reported that age was a main risk marker for disease progression, and Haas[3] reported that progression increased with age and was the highest in the 40–49-year group and then decreased in older age groups.

The males in the 15–24-year group in this study showed a higher rate of periodontal disease progression than females, which indicates that the progression is associated with gender. This is consistent with the results of some studies in other populations.[3] However, there is no other relevant report on this gender-based difference in the Chinese population. It is possible that the effect of gender may differ with different age groups: in the present study, the difference between males and females was not significant in the 25–44 year age group. Therefore, age and gender might be co-variables of progression, as per the results of the present study.

With regard to attachment loss, the majority of the active sites were characterised by gingival recession in the 15–24-year-old subjects, but the contribution by gingival recession decreased with increasing age. Moreover, 26% of the active sites were associated with only increase in PD in the 15–24-year-old subjects. With increase in age, a greater number of active sites were characterised by a combination of gingival recession and increase in PD. More buccal active sites than lingual sites were associated with gingival recession. From the results, it seems that the contribution of PD and gingival resection to attachment loss was influenced by age and site type. This is the only relevant report on this in the Chinese population. In the Norwegian population, Heitz-Mayfield et al.[44] reported that only age was the influential factor for attachment loss: in Norwegians aged <40 years, the majority of attachment loss was found in the form of recession, and in Norwegians aged >50 years, attachment loss was in the form of increase in PD or a combination of increase in PD and recession. In our study, as the subjects approached the age of 25 years, the active sites were mainly in the form of a combination of increase in PD and gingival recession. Thus, the results of the Norwegian study and our study differed for subjects aged <40 years. It is possible that oral hygiene might be an influencing factor; since our study population comprised villagers with poor oral hygiene, deep periodontal pockets occurred as early as the age of 15. Therefore, in populations with poor oral hygiene, periodontal PD may be an important form of attachment loss early on, while in populations with good dental hygiene, recession may be a major form of attachment loss early on.

In this study, the partial mouth protocol was used. In view of new published research, we found that all previously published partial protocols have underestimated prevalence and incidence of periodontal diseases.[45] However, a half-mouth examination of six sites/tooth can conserve time, limit costs and reduce patient fatigue, while providing maximal information.[46]

5. Conclusions

In this study, we demonstrated that in Chinese population without regular dental care, both the initiation of periodontitis and progression of previously existed periodontitis contributed to the natural progression of periodontitis and periodontal pocketing played a greater role with age increasing.

Acknowledgements

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