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ORIGINAL ARTICLE

Natural 4-year periodontal progression of mandibular first molars in Chinese villagers based on radiographic records

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Abstract

Background: To report 4-year natural periodontal progression of mandibular first molars based on radiographic records in 15 to 44-year-old Chinese villagers.

Methods: In 1992 (N = 486) and 1996 (N = 413), panoramic radiographs were recorded. Tooth loss of mandibular first molars was calculated. Relative bone height (RBH), intrabony defect (IBD) depth, and furcation involvement (FI) were measured on 918 and 755 mandibular first molars in 1992 and 1996, respectively. The progression of the three parameters and their relationship with widened periodontal ligament space (WPDL) were analyzed.

Results: In 1992, of 31 lost mandibular first molars, 29 belonged to the 35- to 44-year age group. At 4-year follow-up, five of eight lost teeth belonged to the 35- to 44-year age group. RBH decreased from 83% in 1992 to 77% in 1996. RBH progression was significantly faster in the 25- to 34- and 35- to 44-year age groups than in the 15- to 24-year age group. The mean IBD depth was 2.81 ± 0.55 mm (n = 32) in 1992 and 3.70 ± 0.73 mm (n = 33) in 1996. Prevalence of FI increased from 20.8% to 27.4%. Teeth with WPDL showed greater RBH and IBD progression than those without WPDL (RBH: 12% ± 1% versus 6% ± 0.01%, $P < 0.001$; IBD depth: 0.31 ± 0.08 versus 0.01 ± 0.00 mm, $P < 0.001$). FI-area progression in teeth with WPDL showed a trend of greater expansion than in those without WPDL (0.92 ± 0.18 versus 0.56 ± 0.11 mm^2, $P = 0.051$).

Conclusions: Tooth loss mainly occurred in the 35- to 44-year age group. RBH progression was faster in the 25- to 44-year age group. WPDL was associated with progression of RBH, IBDs, and FI.

KEYWORDS
furcation involvement, intrabony defect, longitudinal study, natural progression, periodontal disease, relative bone height

1 | INTRODUCTION

Periodontal diseases affect a considerable part of the population and lead to resorption of periodontal supportive tissue and eventually tooth loss. Several groups[1–15] have reported the rate and pattern of natural progression of periodontal diseases. With increasing popularity of oral health care, it is becoming difficult to obtain adequate data regarding the natural history of periodontitis. Most reports have analysis limited to clinical parameters such as probing depth, clinical attachment level, and bleeding on probing. Radiographic observation in periodontal epidermiologic aspect are rare.[1–7]

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However, alveolar bone height and furcation involvement (FI) are meaningful and important parameters to reflect the progression of periodontal diseases.

Several studies[1,2] have described the natural annual progression of alveolar bone height. Reportedly the mean natural annual reduction of alveolar bone height ranged from 0.07 to 0.14 mm in individuals aged 25 to 65 years in Sweden over a 10-year period.[2] On the other hand, the mean annual bone loss was 0.11 mm in the total population aged 18 to 68 years in Norway over 2 years.[1] Both aforementioned studies reported natural progression of alveolar bone. In another study conducted in the United Kingdom that included an untreated population over an average duration of 6.6 years,[4] patients with chronic periodontitis showed an alveolar bone loss progression of 0.20 mm/year, while those with aggressive periodontitis showed a progression of 0.30 mm/year. To our knowledge, no study has reported the natural progression of alveolar bone in a Chinese population.

Periodontal bone defects occur as either suprabony or intrabony defects (IBDs). IBDs are defects that occur when the base of the defect is located apical to its bony margin. Papapanou et al.[16] reported that longitudinal bone loss occurred more often in IBDs compared with suprabony defects. Najim et al.[17] reported that the overall prevalence of IBDs in Sweden was 2.2%, and specifically, this prevalence in mandibular first molars was 3.3%. To our knowledge, natural progression of IBDs remains unclear. The etiology factor for development of IBDs is plaque. Several factors could be involved in the formation of such defects, including deep periodontal pockets, form and volume of alveolar bone, thickness of alveolar bone, and occlusal trauma.

FI is another kind of bone defect. The presence of FI in molars almost doubles the risk of tooth loss compared with absence of FI in 10 to 15 years.[18] The reported prevalence of FI ranged from 8.3% to 13.7%.[19,20] However, the natural progression of FI remains unclear. Several factors[21] have been associated with FI, such as deep periodontal pockets,[17] root trunk,[22,23] enamel projection, periapical inflammation,[24] and occlusal trauma.

Widening of the periodontal ligament space is a key sign of occlusal trauma. Radiographic findings of teeth with occlusal trauma include enlargement of the periodontal ligament space and loss of the alveolar hard line during early stages, followed by resorption of the alveolar bone or root resorption and tooth loss during later stages.[25–27] Occlusal trauma was reported as one of the local contributing factors associated with periodontal bone loss.[28] Lindhe et al.[29] reported that angular bony defects and loss of attachment in dogs were influenced by the combined effect of plaque-induced periodontitis and jiggling-type trauma. Nakatsu et al.[30] reported that immune complexes were more abundant in tissues wherein inflammation was accompanied by occlusal trauma than in tissues that showed inflammation without occlusal trauma. Occlusal trauma can be related with the existence of bone loss, IBDs and FI; however, it is unclear whether occlusal trauma can accelerate bone loss, IBDs, and FI.

Periodontal disease presents in different patterns in different tooth types. Molars have the highest rate of tooth loss.[2] First molars are the first teeth to erupt and have the most important functions of mastication and occlusion during the early stages of life. Thus, the most frequently lost teeth among all types of teeth are permanent first molars,[31] particularly mandibular first molars.[17,32,33] Bony defects include IBDs and suprabony defects. Suprabony defects can occur around any type of teeth. However, IBDs and FI are most frequently noted in and are typically located around molars.[34,35] In addition, measurement errors in panoramic radiographic analysis are lower with mandibular molars than with maxillary molars.[36] Thus, mandibular first molars can be considered as representative teeth and are typically chosen for analysis of findings from panoramic radiographs.

The aim of the present study was to re-analyze data acquired between 1992 and 1996 and focus on the radiographic aspect of natural progression of periodontal diseases. The study had two purposes: 1) to report natural periodontal progression in terms of radiographic findings of mandibular first molars in 15 to 44-year-old Chinese villagers with limited dental health care over a 4-year period and 2) to determine the association of widened periodontal ligament space (WPDL) with bone loss.

2 | MATERIALS AND METHODS

A 4-year prospective study was conducted from 1992 to 1996 in a Chinese village of the Chengde city. The village consisted of 2124 inhabitants with limited access to oral health care. Less than half of the villagers had a toothbrush.[7–10] Verbal informed consent was obtained from all patients for this study. The protocol was approved by the Peking University School of Stomatology, and the study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2000.

At baseline, 486 people (15 to 44 years, men = 211, women = 275) were enrolled. In 1996, 413 subjects were re-examined by the same examiner. Panoramic radiographs were taken under the same radiographic conditions by using the same machine. Radiographic images were scanned for digital documentation. The Sketchpad software was used to perform measurements on the radiographic images. Mandibular first molars were selected for analysis. The measurement method used is depicted in Figure 1.

The ratio of residual bone height and full root length was calculated and defined as relative bone height (RBH).[37] Mesial and distal sides of each tooth were analyzed. When a vertical bone defect existed, RBH was measured from the

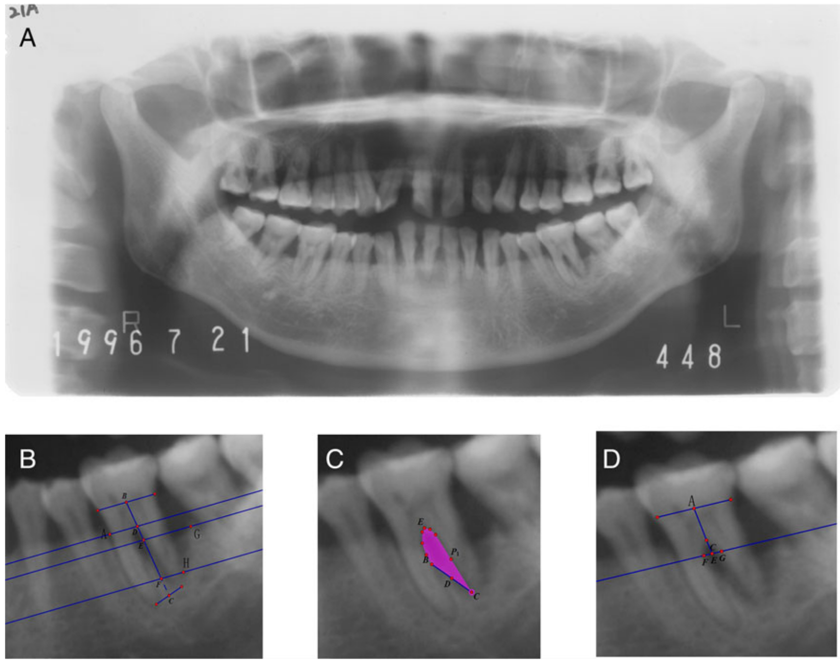

FIGURE 1 Measurement of panoramic radiograph. A) the radiographic graph was scanned into digital document. B) Take the left mandibular first molar for example. First, draw a line from the mesial cemento-enamel junction (CEJ) to the distal CEJ. Second, point B was identified as the midpoint of the line. Point C was the midpoint of mesial and distal root apex. BC was the main axis of the tooth and the other points were projected on it. BC was defined as the root length. Point A was the mesial alveolar crest. Point G was the distal alveolar crest. Point H was the bottom of the distal bone defect. AD, GE, and HF was parallels of CEJ. The ratio of DC and BC was mesial relative bone height (RBH). The ratio of FC and BC was distal RBH. EF was distal intrabony defect (IBD). C) The red area was calculated as area of furcation involvement (FI) by contouring the whole furcation involvement. D) Point C was the fornix of FI. AC was defined as the root trunk. CE was 0.2 cm. EFG was parallel of the CEJ. The angel of FCG was defined as angel of FI

most apical point at the bottom of the defect. The distance between the bottom of the defect and the alveolar crest was defined as the depth of the IBD. The minimum depth to be considered IBDs was 1 mm. FI was defined based on Glickman classification system. Partial radiolucency in the furcation area was defined as degree II; total radiolucency in the furcation area was defined as degree III. Teeth with II/III-degree radiolucency were considered as those with FI radiographically. The area of the FI with partial radiolucency was defined as FI-a. Rates of IBD and FI were calculated at the tooth level. WPDL was recorded as well if the periodontal ligament space was measured to be wider than 0.4 mm. All measurements were performed by a single examiner. Intraexaminer agreement was excellent for IBD and FI detection (reliability coefficient was >0.9).

Statistical analyses were conducted using the independent sample *t* test, Mann-Whitney *U* test, one-way analysis of variance (ANOVA), and χ^2 test.

3 | RESULTS

3.1 | Number of mandibular first molars and tooth loss

In 1992, a total of 31 mandibular first molars were lost among 486 villagers, and subsequently, excluding 23 teeth of residual roots, finally 918 mandibular first molars were included for analysis. In 1996, 39 mandibular first molars were lost among 413 villagers, and subsequently, excluding 32 teeth of residual roots, finally 755 mandibular first molars were included. In 1992, loss of mandibular first molar in the 35- to 44-year age group (n = 29) was much higher than that in the 15- to 24- (n = 0) and 25- to 34-year (n = 2) age groups. The same pattern was observed in 1996. In fact, in 1992, the rate of loss of mandibular first molars in the 35- to 44-year age group was 20.8% (29/139) at subject level, while in 1996, this rate increased to 26.8% (34/127) at subject level. During the following 4 years, eight teeth were lost, of which, five belonged to the 35- to 44-year age group. The lost molars during follow-up had two baseline characteristics: 60% lost first mandibular molars were residual roots and 40% had severe bone resorption (beyond the apical third of the root) at baseline.

3.2 | Change in RBH of mandibular first molars between 1992 and 1996

Overall, the mean RBH was 83% in 1992: specifically, RBH was 88%, 83%, and 77% in the 15- to 24-, 25to 34-, and 35- to 44-year age groups, respectively (Table 1). Of note, the mean RBH decreased significantly as age increased. Moreover, the mean RBH decreased to 77% in 1996. Overall, the mean RBH decreased from 1992 to 1996 in all three age groups, and the progression of RBH was significantly faster in the 25- to 34- (8.5%) and 35- to 44-year (9.6%) age groups than in the 15- to 24-year (3.2%) age group. Furthermore, mesial RBH was almost the same as distal RBH in both 1992 and 1996.

3.3 | Changes in IBD of mandibular first molars between 1992 and 1996

In 1992, the prevalence of IBD was 3.5% at mesial sites (32/918 sites) and 0.44% (4/918 sites) at distal sites. After 4-year follow-up,, the overall incidence of IBD was 0.5% at

TABLE 1 Radiographic analysis of mandibular first molar at site level and tooth level

	1992, age (years)				1996, age (years)			
Parameters	15 to 24	25 to 34	35 to 44	Total	15 to 24 at baseline	25 to 34 at baseline	35 to 44 at baseline	Total
Number of subjects (women, men)	197 (127, 70)	150 (78, 72)	139 (70, 69)	486 (275, 211)	151 (96, 55)	135 (70, 65)	127 (67, 60)	413 (233, 180)
Number of teeth	394	286	238	918	291	250	214	755
Number of teeth loss	0	2	29[a,b]	31	0	5	34[a,b]	39
RBH-mesial mean (SD)	88% (5%)	83% (8%)[a]	77% (13%)[a,b]	83% (9%)	84% (6%)	74% (12%)[a]	69% (13%)[a,b]	77% (12%)
RBH-distal mean (SD)	87% (5%)	82% (7%)[a]	77% (12%)[a,b]	83% (9%)	83% (6%)	73% (11%)[a]	68% (14%)[a,b]	76% (12%)
IBD-mesial, n sites (%)	8 (2.0%)	13 (4.5%)	11 (4.6%)	32 (3.5%)	9 (3.1%)	12 (4.8%)	12 (5.6%)	33 (4.4%)
IBD-distal, n sites (%)	1 (0.25%)[c]	1 (0.35%)[c]	2 (0.84%)[c]	4 (0.44%)[c]	2 (0.69%)[c]	1 (0.40%)[c]	2 (0.93%)[c]	5 (0.66%)[c]
IBD-mesial mean (SD), mm	2.31 (0.33)	2.35 (0.52)	3.72 (0.79)	2.81 (0.55)	3.16 (0.48)	2.95 (0.62)	4.87 (1.05)	3.70 (0.73)
IBD-distal mean (SD), mm	1.14 (0.06)[c]	2.06 (0.12)[c]	6.94 (0.59)[c]	4.27 (0.32)[c]	1.99 (0.15)[c]	2.10 (0.12)[c]	7.25 (0.62)[c]	4.12 (0.35)[c]
FI teeth, n (%)	20 (5.1%)	66 (23.9%)[a]	103 (43.3%)[a,b]	189 (20.8%)	36 (9.1%)	99 (35.9%)[a]	114 (47.9%)[a,b]	249 (27.4%)
FI-a mean (SD) mm^2	0.32 (0.32)	0.59 (0.79)[a]	1.22 (1.85)[a,b]	0.90 (1.40)	0.82 (0.91)	1.06 (1.47)[a]	1.78 (1.99)[a,b]	1.35 (1.71)

RBH = relative bone height; IBD= intrabony defect; FI = furcation involvement; FI-a = area of the radiolucency furcation involvement.
[a]Compared with 15- to 24-year group ($P < 0.05$)
[b]Compared with the 25- to 34-year group ($P < 0.05$)
[c]Compared with the mesial group ($P < 0.05$)

TABLE 2 Relationship between WPDL and RBH of mandibular first molar in 1992 and 1996

	1992			1996		
	RBH ≤50%	RBH >50%	Total	RBH ≤50%	RBH >50%	Total
WPDL (+)	6	48	54	16	39	55
WPDL (−)	8	856	864	21	679	700
Total	14	904	918	37	718	755
Odds ratio	13 (4 to 40)			13 (6 to 27)		
P value[a]	<0.001			<0.001		

WPDL = widened periodontal ligament space; RBH = relative bone height.
[a]Chi-square test.

mesial sites (5/886 sites) and 0.1% at distal sites (1/914 sites). The mean IBD depth at mesial sites was 2.81 mm in 1992, which increased to 3.70 mm in 1996.

3.4 | Changes in FI of mandibular first molars between 1992 and 1996

In 1992, the prevalence of FI was 20.8%; specifically, this rate was 5.1%, 23.9%, and 43.3% in the 15- to 24-, 25- to 34-, and 35- to 44-year age groups, respectively. The prevalence of FI increased significantly as age increased in both 1992 and 1996; FI prevalence increased to 27.4% in 1996.

The average FI-a was 0.90 mm^2 in 1992; specifically, FI-a was 0.32, 0.59, and 1.22 mm^2 in the 15- to 24-, 25- to 34-, and 35- to 44-year age groups, respectively. The average FI-a increased significantly as age increased in both 1992 and 1996; it increased to 1.35 mm^2 in 1996.

3.5 | Relationship between WPDL and RBH of mandibular first molars

In 1992, of the 918 teeth, 904 teeth were with RBH > 50%, whereas 14 were with RBH ≤ 50%. Moreover, among teeth with RBH > 50%, 48 (5.3%) teeth had WPDL (Table 2).

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TABLE 3 Relationship between WPDL and IBDs of mandibular first molar in 1992 and 1996

	1992			1996		
	IBDs (+)	**IBDs (−)**	**Total**	**IBDs (+)**	**IBDs (−)**	**Total**
WPDL (+)	22	32	54	26	29	55
WPDL (−)	14	850	864	11	689	700
Total	36	882	918	37	718	755
Odds ratio	42 (19 to 89)			56 (25 to 125)		
P value[a]	<0.001			<0.001		

WPDL = widened periodontal ligament space; IBDs = intrabony defects.
[a]Chi-square test.

TABLE 4 Relationship between WPDL and FI of mandibular first molar in 1992 and 1996

	1992			1996		
	FI (+)	**FI (−)**	**Total**	**FI (+)**	**FI (−)**	**Total**
WPDL (+)	47	7	54	51	4	55
WPDL (−)	141	723	864	145	555	700
Total	188	730	918	196	559	755
Odds Ratio	35 (15 to 79)			50 (17 to 140)		
P value[a]	<0.001			<0.001		

WPDL = widened periodontal ligament space; FI = furcation involvement.
[a]Chi-square test.

However, of the 14 teeth with RBH ≤ 50%, 6 (42.9%) teeth had WPDL. Chi-square test indicated that WPDL was correlated with RBH ≤ 50%. The same results were seen in 1996.

3.6 | Relationship between WPDL and IBD of mandibular first molars

Of the 918 teeth, 36 teeth had IBD and 882 teeth did not have any IBD. Among teeth with IBD, 22 teeth had WPDL in 1992 (Table 3). However, of the 882 teeth without IBD, only 32 teeth had WPDL. Chi-square test indicated that WPDL was correlated with IBD. The same results were seen in 1996.

3.7 | Relationship between WPDL and FI of mandibular first molars

Of the 918 teeth, 188 teeth had FI and 730 teeth had no FI. Among teeth with FI, 47 teeth had WPDL in 1992 (Table 4). However, of the 730 teeth without FI, only seven teeth had WPDL, indicating a correlation between WPDL and FI. The same results were seen in 1996.

3.8 | Relationship between WPDL and RBH/IBD/FI progression of mandibular first molars during the study period

In Table 5, teeth with WPDL showed greater RBH and IBD progression than those without WPDL (RBH: 12% ± 1% versus 6% ± 0.01%, $P < 0.001$; IBD depth: 0.31 ± 0.08 versus 0.01 ± 0.00 mm, P <0.001). FI-area progression in teeth with WPDL showed a trend of greater expansion than in those without WPDL (0.92 ± 0.18 versus 0.56 ± 0.11 mm^2, $P = 0.051$).

TABLE 5 Relationship between WPDL and RBH/IBDs/FI progression of mandibular first molar during the 4 years

Parameters	RBH progression Mean ± SD	IBDs progression Mean ± SD	FI-a progression Mean ± SD
WPDL (+)	0.12 ± 0.01	0.31 ± 0.08	0.92 ± 0.18
WPDL (−)	0.06 ± 0.00	0.01 ± 0.00	0.56 ± 0.11
P value[a]	<0.0001	<0.0001	0.051

WPDL = widened periodontal ligament space; RBH = relative bone height; IBDs = intrabony defects; FI = furcation involvement; FI-a = area of the radiolucency furcation involvement.
[a]Mann-Whitney test.

4 | DISCUSSION

The present study was a 4-year research (1992 to 1996) on natural periodontal disease progression in Chinese villagers with limited dental care. Previous studies have mainly focused on clinical examinations.[7–10] This rare study reports the natural periodontal progression of mandibular first molars based on radiographic records in 15- to 44-year-old Chinese villagers with virtually no access to regular dental care. The hypothesis was that the subjects with poor dental care have more tooth loss and more progression of periodontal diseases. The objectives were to report the characteristics of progression based on the four aspects (tooth loss, RBH, IBD, FI) on radiographic records and the to determine the association of WPDL with bone loss. The main results were as following. Tooth loss mainly occurred in the 35- to 44-year age group. RBH decreased by 1.5% annually. RBH progression was faster in the 25- to 44-year age group. The prevalence of mesial IBD was significantly higher than that of distal IBD. The annual rate of FI-involved teeth was 1.65% based on radiographic examination. WPDL was associated with progression of RBH, IBDs, and FI.

Based on the analysis, loss of mandibular first molar in the 35- to 44-year age group was much higher than that in the 15- to 34-year age group in both 1992 and 1996. This was consistent with results from a study conducted in Brazil,[31] wherein tooth loss in the 35- to 45- and 46- to 64-year age groups was higher than that in the 20- to 34-year age group. Thus, more attention should be paid to the periodontal status and health of subjects aged >35 years.

In 1992, the rate of loss of mandibular first molars in the 35- to 44-year age group was 20.8%, while in 1996, this rate increased to 26.8%. The annual natural progression rate of loss of mandibular first molars in the 35- to 44-year age group was 1.5%. In a study about natural progression of periodontal diseases, Papapanou et al.[2] reported that the mean number of teeth lost over the 10-year period was 3.8; however, the tooth loss rate of mandibular first molars specifically was not referred. In another study, Yoshino et al[32] reported that mandibular first molars were missing in 26.7% of men and 36.2% of women among 40-year-old Japanese subjects and in 35.3% of men and 29.8% of women among 60-year-old Japanese subjects; however, this was a cross-sectional study. Dannewitz et al.[38] reported that among 1,015 molars, 50 molars were extracted during 10 years after active periodontal therapy; the annual tooth loss was 0.5% after periodontal therapy. The first two reports were about untreated people, the last two reports were for the specific mandibular first molars. Nevertheless, reports regarding the annual natural progression of tooth loss of mandibular first molars are limited.

In the present study, RBH decreased annually by 1.5%. A study in Sweden reported that the mean annual reduction of alveolar bone height was 0.07 to 0.14 mm in 25- to 65-year-old subjects.[2] In another study conducted in the United Kingdom, Onabolu et al.[4] reported that in patients aged >18 years with chronic periodontitis, the progression rate of alveolar bone loss was 0.20 mm/year, and this rate was 0.30 mm/year in those with aggressive periodontitis. In the present study, the bone height decreased annually by 0.19 mm, which was greater compared with some previous reports, however slightly lower than some others. A possible reason could be the poor status of dental care, which could reflect natural progression of bone level. Another reason could be the differences in population and ethnicity.

At baseline, RBH decreased as age increasing, consistent with previous reports.[39] In this study, RBH progression was significantly faster in the 25- to 44-year age group than in the 15- to 24-year age group. Papapanou et al.[2] reported that initially, 70-year-old individuals showed a significantly greater annual rate of bone loss, which was 0.28 mm, than the individuals aged <70 years. Albandar et al.[1] reported that the rate of bone loss increased rapidly between 33 and 56 years of age, while a different pattern was observed in individuals from the 18- to 32- and 57- to 68-year age groups. In the present study, alveolar bone loss started to increase at the age 25, which was lower than previous reports.[1,2] Differences in the population studied and poorer dental care in Chinese villagers could explain these results. Thus, based on our study, more attention should be paid to oral health of villagers aged > 25 years to prevent rapid alveolar bone loss.

Interestingly, RBH ≤ 50% (bone resorption to more than half of the root length) was correlated with WPDL, which means that teeth with WPDL had more bone resorption than those without WPDL. WPDL is an important manifestation of occlusal trauma on panoramic radiographs.[25–27] Occlusal trauma has been considered as one of the local contributing factors associated with periodontal bone loss,[28,30] which has been proved in both animal models and human studies. Jin et al. [27] reported that radiographically, teeth with WPDL had deeper probing depth, more attachment loss, and lower bone height compared with those without WPDL. A significant increase in probing depths was noted in teeth with occlusal discrepancies, and when left untreated, these were associated with progression of periodontal disease.[40] In the present study, teeth with WPDL showed greater progression in RBH compared with those without WPDL, which was consistent with previous reports.

Moreover, in this study, IBDs were noted in mandibular first molars. In addition, the prevalence of mesial IBD was significantly higher than that of distal IBD in both 1992 and 1996, which was consistent with previous reports.[39,41–43] There appears to be no compelling biological reason for this observation; however, the development of periodontal disease at any site cannot be entirely explained by the etiological factors described here alone. Occlusal force could be a possible reason as well. As we know, the direction of occlusal force is not exactly the same as the axis of mandibular first molars, which may lead to stress concentration at mesial alveolar bone. In the present study, the prevalence of IBD was 3.5% at mesial sites (32/918 sites) and 0.44% (4/918 sites) at distal sites in 1992, concordant with previous reports.[16,17] Najim et al.[17] reported that in Sweden, the prevalence of IBD was 3.3% in mandibular first molars and 2.2% in all types of teeth. To our knowledge, the natural progression of IBDs remains unknown. This is perhaps the first report regarding the natural progression of IBDs in a Chinese population. In this natural progression study, the mean IBD depth at mesial sites with IBD increased by 0.22 mm/year.

Moreover, the existence of IBD was correlated with WPDL in this study. WPDL has been an important sign of occlusal trauma on panoramic radiographs.[25–27] According to a previous report, occlusal trauma was the most frequent etiological factor (55.8%) for formation of IBDs.[44] In our study, teeth with occlusal trauma indicated greater progression of IBD than did those without WPDL. To our knowledge, ours is a rare report about the relationship between WPDL and the natural progression of IBD depth.

Furthermore, the prevalence of FI increased from 20.8% in 1992 to 27.4% in 1996. The annual rate of FI-involved teeth was 1.65% according to radiographic examination. FI is an important prognostic factor for loss of molars.[45–47] The presence of FI almost doubles the risk of tooth loss for molars in 10 to 15 years.[18] FI of II and III degree have been associated with increased risk of tooth loss.[48,49] Thus, more attention should be paid to any signs of FI. Albandar et al. reported an FI prevalence of 13.7% in the United States based on oral examination of the general population (aged ≥30 years),[20] which was lower than the prevalence reported in our study. In another study by Najim et al.,[19] the prevalence of molars with FIs was 8.3% in Sweden. Both aforementioned studies were cross-sectional. The difference in prevalence rates between both studies could be explained by differences in ethnicity. Root trunk length could be one of the explanations as well. In our study, the mean root trunk length in mandibular first molars was 2.01 ± 0.42 mm based on panoramic radiographs. In a population from Brazil,[50] this value was 1.37 ± 0.78 mm at buccal sites and 2.04 ± 0.89 mm at lingual sites. Thus, the root trunk length in the Chinese population seems slightly greater than that in the Brazilian population. Root trunk length is a key factor in development of FI: the shorter the root trunk, the less bone loss is required before the furcation is involved.

In this study, we found a correlation between WPDL and FI. Several factors[21] might be associated with development of FI, such as bone loss, deep periodontal pockets,[17] root trunk length,[22,23] enamel projection, and periapical inflammation.[24] Najim et al.[19] reported that periodontal pockets, age, and smoking were risk factors for FI. However, it was unclear whether WPDL contributed to FI. In the present study, FI-a progression in teeth with WPDL showed a trend toward greater expansion than did those without WPDL. Additional studies must be conducted to clarify this further in the future.

The study had certain limitations. Only mandibular first molars were included. Measurements of maxillary first molars could not be accurately performed on panoramic radiographs as furcation was overlapped by palatal roots of maxillary first molars. Meanwhile, measurements of FI on panoramic radiographs had its own limitations, which may be overestimated or underestimated as clinical grading of FI. In this study, we did only primary analysis at patient, tooth and site level separately. The results of multilevel logistic regression analysis would be performed in further study.

5 | CONCLUSIONS

In the present study, tooth loss was mainly noted in 35- to 44-year-old Chinese villagers. RBH decreased by 1.5% annually. The progression of RBH was significantly faster in the 25- to 44-year age group than in the 15- to 24-year age group. The prevalence of mesial IBD was significantly higher than that of distal IBD. The annual rate of FI-involved teeth was 1.65% based on radiographic examination. WPDL was associated with progression of RBH, IBDs, and FI.

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