The Relationship Between Different Types of Caries and Periodontal Disease Severity in Middle-Aged and Elderly People: Findings from the 4th National Oral Health Survey of China

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Abstract

Background: To explore the relationship between different types of caries and periodontal disease severity in middle-aged and elderly people in China.

Methods: The study population consisted of 4,387 middle-aged and 3,225 elderly subjects. Caries was divided into three types: type A, crown caries; type B, lesions involving both the crown and root, which represents mixed type; and type C, root caries. These three types together represent the overall caries situation, which we call type ABC. Caries was quantitated by decayed and filled teeth (DFT index). Periodontitis was evaluated by clinical attachment loss.

Results: Middle-aged people with periodontitis had a significant association with DFT of type ABC (OR: 1.09, 95% CI: 1.06-1.11), type A (OR: 1.05, 95% CI: 1.02-1.08), type B (OR: 1.20, 95% CI: 1.16-1.28) and type C (OR: 1.36, 95% CI: 1.15-1.60). Elderly people with periodontitis had a significant association with DFT of type ABC (OR: 1.05, 95% CI: 1.03-1.07), type B (OR: 1.07, 95% CI: 1.05-1.10) and type C (OR: 1.30, 95% CI: 1.19-1.42) but not with type A.

Conclusions: Different types of caries in middle-aged people, the overall caries and caries types involving the root surface in elderly people were significantly associated with periodontal disease severity.

Background

Dental caries and periodontitis are the most common diseases in the oral cavity among adults. Both diseases are the primary cause of tooth loss and can lead to negative impacts upon quality of life. Over the years, the relationship between the two diseases is still controversial. Although several studies have shown a positive correlation between the two diseases [1-10], there are also some studies showing a negative correlation [11-13] or others showing no association [14].

The reasons for the positive correlation include common social-behavioural factors, such as age, gender, poor oral hygiene, smoking status, etc. [15]. In addition, there is evidence that host genetic factors play a moderate role in caries and periodontitis [15]. The main reason for the inverse correlation is different bacteriological spectrum. A great deal of evidence points to *Streptococcus mutans* as the primary cariogenic bacterium, while periodontitis is associated with specific gram-negative anaerobic bacteria, such as *Porphyromonas gingivalis*. A negative association has been reported between salivary levels of *S. mutans* and *P. gingi*valis, which was found in subjects with varying severity of caries and periodontitis, indicating that an inverse correlation exists between the two diseases [13].

Caries can be divided into three types according to the location of occurrence: crown caries, root caries and mixed type caries affecting both the crown and root. According to instructions from the WHO, if a carious lesion involves both the crown and the root, the possible site of origin of the carious lesion should be recorded as the site of decay. When it is impossible to determine the origin of the lesion, both the crown and root should be recorded as decayed [16]. In fact, in a large-scale oral epidemiological

examination, it was very difficult to confirm the origin of caries in most cases. Therefore, it is difficult to classify the caries involving both the crown and root as coronal caries or root caries. As far as we know, in the study of the relationship between the two diseases, few studies have been able to clearly point out the specific types of caries they studied [1, 7]. It has been pointed out that the detection methods of caries could be a plausible explanation for discrepancies found in the relationship between caries and periodontitis [12]. Due to the controversial relationship between the two diseases, it is necessary to classify the caries.

Inconsistencies in subject selection could be another plausible explanation for discrepancies found between the two diseases [12]. It has been pointed out that studies reporting an inverse association between the two diseases are mostly based on selected patients who were in a young population no more than 20 years of age having juvenile periodontitis, which was recognized as having increased susceptibility to periodontitis [14]. Like many diseases, age is an important factor that is greater than other known risk factors on caries and periodontitis to explain the variation in occurrence. The role of age in both diseases has been attributed to accumulated exposure. In addition, a recent study showed that susceptibility to the two diseases could change with ageing [17].

Taken together, the objective of this study is to explore the relationship between different types of caries and periodontal disease severity considering different types of caries in middle-aged and elderly people respectively from the 4th National Oral Health Survey in China. As caries and periodontitis are related to many social and behavioural background factors, ordered logistic regression was used for controlling relevant confounders.

Methods

Sampling and clinical examining method

The present study was a part of the 4th National Oral Health Survey, which is the most comprehensive oral health survey to date in China, carried out in 2015-2016. A multistage stratified sampling was used to recruit adults from all 31 provinces, municipalities and autonomous regions of mainland China. The probability proportional to size (PPS) method was used to randomly select subjects [18]. A total of 4,410 35- to 44-year-olds and 4,431 65- to 74-year-olds attended the survey. The exclusion criterion of this analysis was participants who had fewer than 20 teeth [3, 19] and periodontal status that cannot be examined for any reason, such as non-standard fixed prosthesis that cover the gingiva, or calculus is present to such an extent that periodontal examination is not possible.

The latest WHO recommendations (2013) were used for clinical oral examinations. The examinations were conducted by three trained licensed dentists, while three other trained individuals with clinical experience acted as recorders in each province. Examinations were conducted with a mobile dental chair, using artificial light, a disposable dental mirror, and a standard WHO Community Periodontal Index (CPI) probe [18].

Variables

Independent variables

Caries were recorded for all tooth surfaces, but observations were recorded by tooth. We divided caries into three types: type A, caries or a filling on the crown, which represents crown caries; type B, caries or a filling involving both the crown and root, which represents mixed type; and type C, caries or a filling on the root, which represents root caries. These three types together represent the overall caries situation, which we call type ABC (Figure 1). Because residual roots involve both the crown and root, we classified residual roots as type B. The number of decayed and filled teeth (DFT) was calculated to analyse its relationship with periodontitis. The kappa values of the inter-examiners' reliabilities for the examination of dental caries were both 0.97 in the middle-aged and elderly group [18, 20].

Dependent variables

Periodontal disease severity was evaluated by clinical attachment loss (CAL) by tooth, including third molars. Probing was performed "walked around" along gingival crevices with a standardized force of no more than 20 grams. Each tooth was recorded according to severity. CAL was scored as 0 (0-3 mm), 1 (4 -5 mm), 2 (6-8 mm), 3 (9 -11 mm), 4 (12 mm or more), 9 (tooth excluded) and X (tooth not present). Before the field investigation, examiners accepted training, and every examiner and a reference examiner carried out the examination on 10 to 15 subjects per group to assess the consistency. The kappa value was calculated and was more than 0.6, which suggested good reliability [18].

Covariates

A face-to-face interview was conducted to collect information on participants' demographic characteristics: gender, area, education level, and household income per capita. Oral health behaviours: frequency of dessert consumption, frequency of tooth brushing, use of dental floss and toothpicks, smoking status, and alcohol consumption. Diabetes history [21, 22].

Statistical analysis

For analysis, periodontitis was divided into three groups according to CAL: ≤ 3 mm, 4-5 mm, and ≥ 6 mm. Data analysis was carried out using SPSS 20.0. Categorical and continuous variables may have influenced caries status, and periodontitis was analysed using a Chi-square test and a Kruskal Wallis test, respectively. Those variables with $P < 0.05$ were tested further in an ordered logistic regression to analyse the association between the two diseases with consideration of the other factors. Statistical analyses did not include missing values and the individual who preferred not to answer.

Results

A total of 4,387 subjects 35-44 years old and 3,225 subjects 65-74 years old were included in the analysis (Figure 2).

Table 1 shows the results of bivariate analysis of the characteristics of participants in relation to periodontal attachment loss in the 35 to 44-year-old group. We found gender, area, education level, smoking status, tooth brushing frequency, use of dental floss, use of toothpicks, drinking alcohol, household income per capita and diabetes were significantly associated with periodontal disease severity ($P < 0.05$). To control for confounding factors, ordered logistic regression analyses were performed. Table 2 shows the association between the number of DFT and periodontal disease severity in the 35 to 44-year-old group. Adults with periodontitis had a significant association with DFT of type ABC (OR: 1.09, 95% CI: 1.06-1.11), type A (OR: 1.05, 95% CI: 1.02-1.08), type B (OR: 1.20, 95% CI: 1.16-1.28) and type C (OR: 1.36, 95% CI: 1.15-1.60).

Table 3 shows the results of bivariate analysis of the characteristics of participants in relation to periodontal status in the 65 to 74-year-old group. We found gender, area, smoking status, tooth brushing frequency, drinking alcohol and household income per capita were significantly associated with periodontal disease severity ($P < 0.05$). Table 4 shows the association between the number of DFT and periodontal disease severity in the 65 to 74-year-old group. Elderly people with periodontitis had a significant association with DFT of type ABC (OR: 1.05, 95% CI: 1.03-1.07), type B (OR: 1.07, 95% CI: 1.05-1.10) and type C (OR: 1.30, 95% CI: 1.19-1.42), but not with type A (OR: 0.98, 95% CI: 0.95-1.02, $P = 0.331$).

Discussion

The commonly used criteria for defining periodontitis are probing depth (PD) and CAL. PD reflects the current situation of periodontitis, and CAL reflects the long-term accumulation of periodontal damage. Because caries and periodontitis are long-term chronic destructive diseases, the past cumulative lifetime experience of periodontitis is reflected by CAL measurements. Therefore, it is recommended to use this measure to analyse the risk factors of periodontitis in epidemiological studies [23].

DMFT, DT and DFT are the most commonly used indices to evaluate caries status and experience. In people aged 30 years or older, the M component of the DMFT index refers to the loss of teeth caused by any reason. To avoid the overestimation of the true extent of caries, we use the DFT index to analyse caries experience.

Previous studies on the relationship between caries and periodontitis have rarely clearly described whether the caries studied were crown caries, root caries, or mixed type. In recent years, there have been two articles clearly defining the types of caries studied—one was crown/root caries [1], and the other was crown caries [7]. Some studies have pointed out that, when we encounter type B caries, we do not know whether to classify it as crown caries or root caries. This is a measurement issue more than a diagnostic issue [24]. The relationship between caries and periodontitis in different locations for caries may be different, so we divided the types of caries in this way, hoping to further understand the relationship between caries and periodontitis.

We found all four caries types (ABC/A/B/C) were positively correlated with periodontitis in the middle-aged group, and three caries types (ABC/B/C) were positively correlated with periodontitis in the elderly group. In the past, few articles have discussed the relationship between the two diseases according to different age groups. There are studies reporting a positive correlation between caries and periodontal disease severity in adults. Al Qobaly et al. found individuals aged 35 years or older with periodontitis had a higher risk of coronal and root caries in England, Northern Ireland and Wales [1]. Hyman et al. reported that untreated coronal caries surfaces of US individuals aged 20 years or older was positively correlated with mean CAL [7]. Mattila et al. reported a positive association between PD and the DT index in Finnish adults who were 30 years and older [6]. Strauss et al. reported a positive association between periodontitis and the DT index of Chilean adults aged between 35 and 44 years [2]. The positive association could be explained by the common socioeconomic status they shared. Socioeconomic status seems to influence relevant health behaviours, such as diet, oral hygiene, smoking and the patterns of seeking professional prevention or treatment [15]. In our analysis, gender, area, smoking status, tooth brushing frequency and household income per capita showed a significant association with periodontitis in both age groups. As we know, both caries and periodontal diseases are bacterial infectious diseases. Although the microbiological profiles of the two are different, poor oral hygiene is considered one of the main common risk factors, which could provide enough fermentable carbohydrates for bacterial reproduction and subsequently increase the prevalence of the two diseases [1, 15]. In addition, smoking status has been proven to be another important health behaviour that is a common risk factor for both diseases [15]. Furthermore, it has been demonstrated that host genetics has a moderate role in contributing to the susceptibility of both caries and periodontal disease. Although no common genetic genes were found, pleiotropy (one gene influences two or more seemingly unrelated phenotypic traits) in caries and periodontal disease may exist. Hence, with regards to the role of genetics, more analysis of pleiotropy is needed to unravel the mechanism to better understand the genetic association of caries and periodontal disease accumulating in the same person [15].

Type A caries were shown to have no relationship, but types B and C were positively associated with periodontitis in the elderly group in our study. In the middle-aged group, the DFT index increased with the aggravation of periodontitis, while in the elderly, the group with the most severe CAL (≥ 6 mm) had the lowest DFT. Tooth loss may be a cause. With the increase of age, the tooth loss rate of the elderly increased significantly, and the most frequent occurrence of tooth extraction due to periodontitis should be in the group with CAL ≥ 6 mm. But because of the cross-sectional study, we could not investigate the specific reasons for tooth extraction. Carious lesions of both types B and C involve the root surface. Periodontal attachment loss could lead to exposure of the root surface. As a result of poor oral hygiene, root caries commonly presents as a progressive lesion in patients with periodontitis [25]. The positive correlation between types B and C caries and periodontitis is consistent with a recent systemic review. Root caries incidence or increment has been reported to be associated with patients having periodontal disease [17].

This is the first study to analyse the relationship between caries and periodontal disease in a representative national sample of Chinese adults. We discuss the relationship between the two diseases

by age group, because the risk factors, susceptibility of both diseases, and especially the number and causes of missing teeth in different age groups are different. However, there are some potential limitations in this study that should be addressed. First, due to the cross-sectional data of this study, the causal relationship between caries and periodontitis cannot be concluded. Second, we were obligated to identify periodontitis using CAL instead of definitions of periodontitis, such as that described by the Centers for Disease Control and Prevention and the American Academy of Periodontology (CDC–AAP).

Conclusions

A positive association between different caries types and periodontal disease severity was found in middle-aged people in China. Except crown caries, the overall caries and caries types involving the root surface were positively associated with periodontal disease severity in elderly people.

Abbreviations

CAL: Clinical attachment level; CDC–AAP: Center for Disease Control and Prevention and the American Academy of Periodontology; CPI: Community Periodontal Index; DFT: Decayed and filled teeth; PD: Probing depth; PPS: Probability proportional to size; WHO: World Health Organization

Declarations

Ethics approval and consent to participate

This study was approved by the Stomatological Ethics Committee of the Chinese Stomatological Association (Approval no. 2014-003). Informed written consent was obtained from each participant.

Consent for publication

Not applicable.

Availability of data and materials

The datasets analysed in this study are available from the corresponding authors on reasonable request.

Competing interests

The authors have stated explicitly that there are no conflicts of interest in connection with this article.

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Authors' contributions

Dr Li Xia YU contributed to the data analysis and preparation of the manuscript; Drs Xing WANG, Xi Ping FENG, Bao Jun TAI, De Yu HU, Bo WANG, Chun Xiao WANG, Shu Guo ZHENG, Xue Nan LIU, Wen Sheng RONG, Wei Jian WANG, Yan SI, and Huan Cai LIN trained the investigators, designed and supervised the survey; Drs Yan SI and Huan Cai LIN contributed to the design of the study, general supervision of the research group, and critically revised the manuscript for important intellectual content.

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Tables

Table 1 Bivariate analysis of participant characteristics in relation to periodontal status in the middle-aged group.

Variables	CAL≤3mm N= 2938	CAL=4-5mm N= 1118	CAL≥6mm N= 331	*P* value [a]
Gender (%)				<0.001
Female	54.4	44.8	30.8	
Male	45.6	55.2	69.2	
Area (%)				<0.001
Urban	52.6	45.4	52.6	
Rural	47.4	54.6	47.4	
Educational level (%)				<0.001
≤12 years	69.0	78.4	81.0	
>12 years	31.0	21.6	19.0	
Smoking status (%)				<0.001
Never	70.8	61.2	53.2	
Current (former)	29.2	38.8	46.8	
Tooth brushing frequency (%)				<0.001
< Once per day	4.6	10.1	13.3	
≥ Once per day	95.4	89.9	86.7	
Use of dental floss (%)				<0.001
No	93.8	96.8	96.7	
Yes	6.2	3.2	3.3	
Use of toothpick (%)				<0.001
No	57.0	50.4	43.5	
Yes	43.0	49.6	56.5	
Drinking alcohol (%)				0.019
Ceased	2.3	2.9	4.5	
Scarcely/never	85.4	82.5	78.9	
Daily	4.4	5.2	5.4	
Weekly	7.8	9.5	11.2	
Missing values [b]	0.1	0.0	0.0	

Frequency of dessert consumption (%)				0.156
< Twice a day	97.5	98.5	97.9	
≥ Twice a day	2.5	1.5	2.1	
Household income per capita (%)				<0.001
Less than RMB5,000/person	18.7	24.8	28.4	
RMB5,000 to RMB15,000/person	32.2	30.5	32.9	
More than RMB15,000/person	33.4	28.4	26.6	
Prefer not to answer [c]	15.7	16.3	12.1	
Diabetes (%)				<0.001
No	98.5	97.9	94.9	
Yes	1.5	2.1	5.1	

[a] Chi-square test.

Covariates with $P < 0.05$ were included in the ordered logistic regression.

[b,c] Statistical analyses did not include missing values and the individual who preferred not to answer.

Table 2 The association between dental caries and periodontal disease severity in the middle-aged group.

DFT (mean ± SD)	CAL≤3mm N= 2938	CAL=4-5mm N= 1118	CAL≥6mm N= 331	*P* value [a]	Adjusted *P* value and OR (95%CI) [b]
Type ABC	1.92 ± 2.69	2.40 ± 3.08	2.91 ± 3.42	<0.001	<0.001 1.09 (1.06, 1.11)
Type A	1.52 ± 2.22	1.66 ± 2.32	1.67 ± 2.18	0.024	0.001 1.05 (1.02, 1.08)
Type B	0.37 ± 1.13	0.69 ± 1.55	1.11 ± 2.10	<0.001	<0.001 1.20 (1.16, 1.28)
Type C	0.03 ± 0.28	0.05 ± 0.41	0.13 ± 0.62	<0.001	<0.001 1.36 (1.15, 1.60)

[a] Kruskal Wallis test.

[b] Ordered logistic regression adjusted for gender, area, education level, smoking status, tooth brushing frequency, use of dental floss, use of toothpick, drinking alcohol, household income per capita and diabetes.

Table 3 Bivariate analysis of participant characteristics in relation to periodontal status in the elderly group.

Variables	CAL≤3mm N= 728	CAL=4-5mm N= 1202	CAL≥6mm N= 1295	*P* value [a]
Gender (%)				<0.001
Female	58.7	53.4	42.2	
Male	41.3	46.6	57.8	
Area (%)				0.040
Urban	56.7	50.9	52.1	
Rural	43.3	49.1	47.9	
Educational level (%)				0.492
≤12 years	92.4	93.3	93.9	
>12 years	7.6	6.7	6.1	
Smoking status (%)				<0.001
Never	70.1	68.1	55.8	
Current (former)	29.9	31.9	44.2	
Tooth brushing frequency (%)				<0.001
< Once per day	11.1	15.3	17.8	
≥ Once per day	88.9	84.7	82.2	
Use of dental floss (%)				0.365
No	97.5	97.6	98.3	
Yes	2.5	2.4	1.7	
Use of toothpick (%)				0.131
No	46.8	42.2	44.4	
Yes	53.2	57.8	55.6	
Drinking alcohol (%)				0.030
Ceased	7.3	8.8	9.3	
Scarcely/never	80.9	79.5	74.9	
Daily	8.2	8.2	10.9	
Weekly	3.6	3.6	4.8	
Missing values [b]	0.0	0.0	0.1	

Frequency of dessert consumption (%)				0.237
< Twice a day	98.5	98.8	98.0	
≥ Twice a day	1.5	1.2	2.0	
Household income per capita (%)				0.040
Less than RMB5,000/person	24.2	29.9	29.9	
RMB5,000 to RMB15,000/person	26.9	23.3	24.4	
More than RMB15,000/person	29.7	27.8	27.2	
Prefer not to answer [c]	19.2	19.0	18.5	
Diabetes (%)				0.948
No	87.1	87.3	87.6	
Yes	12.9	12.7	12.4	

[a] Chi-square test.

Covariates with $P < 0.05$ were included in the ordered logistic regression.

[b,c] Statistical analyses did not include missing values and the individual who preferred not to answer.

Table 4 The association between dental caries and periodontal disease severity in the elderly group.

DFT (mean ± SD)	CAL≤3mm N= 728	CAL=4-5mm N= 1202	CAL≥6mm N= 1295	*P* value [a]	Adjusted *P* value and OR (95%CI) [b]
Type ABC	3.35 ± 4.26	4.00 ± 4.28	4.30 ± 4.49	<0.001	<0.001 1.05 (1.03, 1.07)
Type A	1.46 ± 2.19	1.53 ± 2.10	1.24 ± 1.80	0.002	0.331 0.98 (0.95, 1.02)
Type B	1.76 ± 3.35	2.18 ± 3.25	2.65 ± 1.15	<0.001	<0.001 1.07 (1.05, 1.10)
Type C	0.13 ± 0.57	0.29 ± 1.05	0.41 ± 1.15	<0.001	<0.001 1.30 (1.19, 1.42)

[a] Kruskal Wallis test.

[b] Ordered logistic regression adjusted for gender, area, smoking status, tooth brushing frequency, drinking alcohol and household income per capita.

Figures

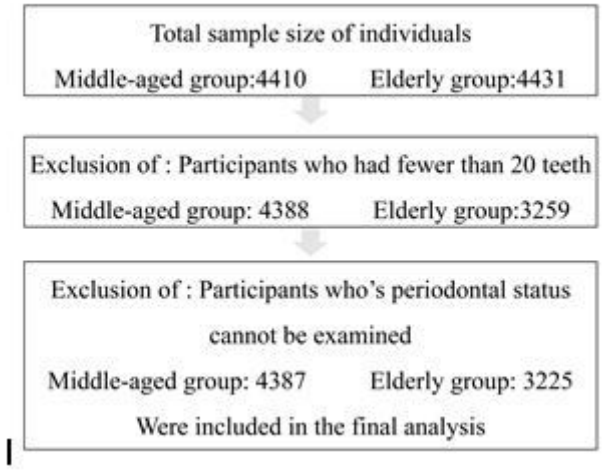

Figure 1

Flow chart of data collection.

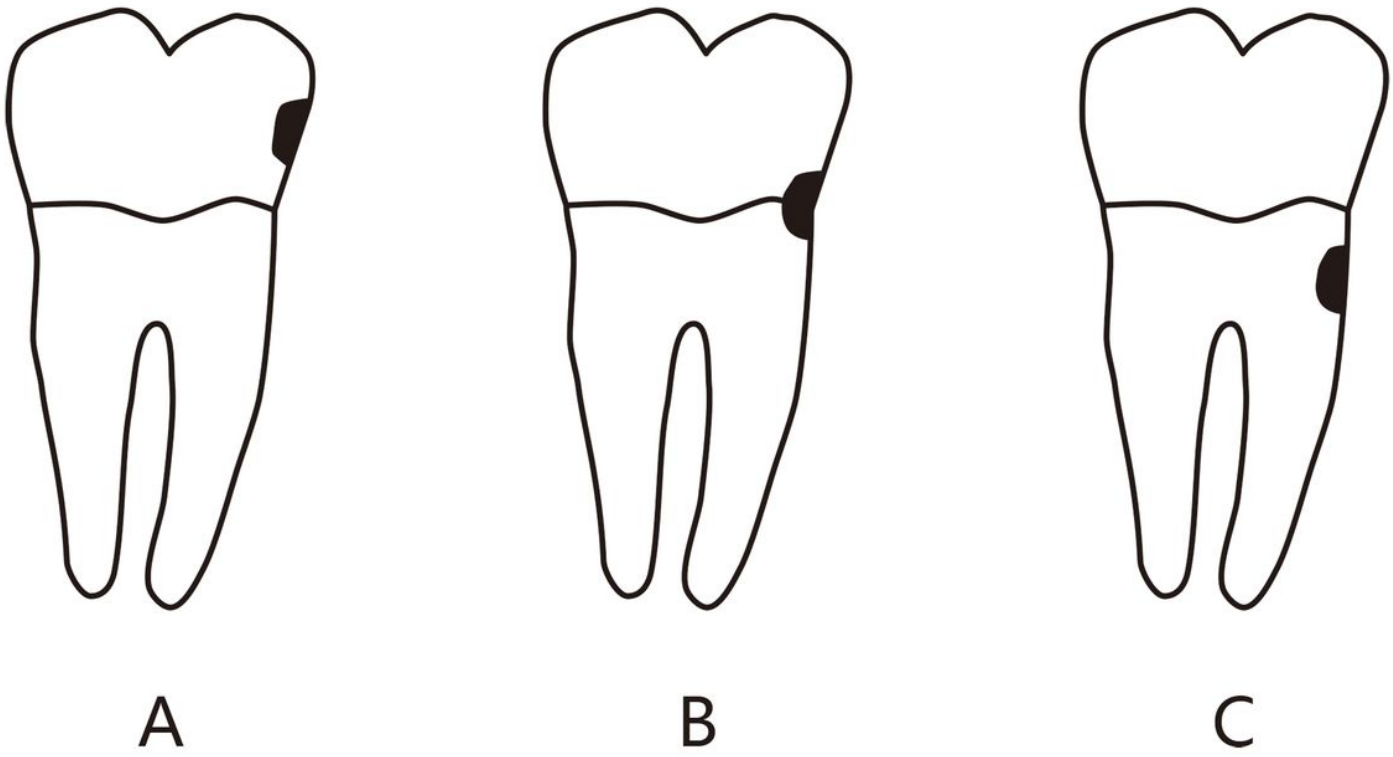

Figure 2

Types of dental caries: which are divided according to the occurrence location. Legends: Type A, caries or a filling on the crown which represents crown caries. Type B, caries or a filling involve both the crown and root which represents mixed type. Type C, caries or a filling on the root which represents root caries. These three types together represent the overall caries situation, which we call type ABC.