

Association Between Chronic Periodontal Disease and Erectile Dysfunction: A Case–Control Study

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Abstract

Erectile dysfunction (ED) and chronic periodontal disease (CPD) share mutual risk factors, and the incidence of ED is increasing among young adults. The relation of CPD and ED remains obscure due to inconsistent clinical evidence. This study aimed to further assess the relationship between CPD and ED using the Community Periodontal Index of Treatment Need (CPITN) and the International Index of Erectile Function (IIEF). Totally, 202 adult men were included, with 100 subjects with ED in the case group and 102 subjects without ED undergoing routine dental examinations in the control group. The IIEF questionnaire was used to assess the severity of ED, and CPD was assessed through the Community Periodontal Index (CPI) score. Periodontal assessments were performed by one single calibrated examiner. Logistic regression analysis was performed for the association between CPD and ED. After adjustment for age, smoking status, tooth brushing time, education level, monthly income, tooth brushing frequency, and gum bleeding, higher CPI score was identified to be associated with a greater risk of ED (odds ratio [OR] = 2.755, 95% confidence interval [CI] = [1.400, 5.423], $p = .003$), suggesting that CPD was positively associated with the odds of ED. CPD was getting more severe with the progress of ED ($p < .05$). Men with ED could be encouraged to receive routine dental examinations and appropriate preventive dental measures to maintain oral and periodontal health.

Keywords

periodontal disease, erectile dysfunction, case–control study

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Introduction

Chronic periodontal disease (CPD) generally refers to the common inflammatory disorders of gingivitis and periodontitis that result from the response of a susceptible host to specific mixed infections induced by periodontopathic microorganisms (Pihlstrom et al., 2005; Saho et al., 2019; Van Dyke & Sima, 2020). Clinically, CPD can not only lead to swollen gums, receding gums and associated tooth hypersensitivity, tooth mobility, impaired mastication, and finally, tooth loss (Darby, 2015; Jin et al., 2016), but also influence the initiation or progression of systemic diseases, such as cardiovascular diseases (CVDs), respiratory diseases, diabetes, osteoporosis, impaired recognition function, and obesity (Borgnakke, 2015; Kinane et al., 2017; Otomo-Corgel et al., 2012).

Erectile dysfunction (ED) is defined by the National Institute of Health as the persistent inability to achieve and

maintain an erection sufficient for satisfactory sexual performance (Lue, 2000; Shamloul & Ghanem, 2013). ED is highly prevalent and affects not only the physical and

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mental health of the patients, but also that of their partners (McMahon, 2019). It is projected that nearly 322 million men worldwide will suffer from ED in 2025 (Ayta et al., 1999). ED has traditionally been deemed a disease of old age; however, recent evidence indicates an growing incidence of ED among men below 40 years, a trend that may be underestimated due to underreporting of younger patients (Nguyen et al., 2017; Pozzi et al., 2020; Shamloul & Ghanem, 2013).

ED and CPD share mutual risk factors, such as smoking, age, depression, diabetes mellitus, and CVD (Wang et al., 2016). CPD is thought to impact all general pathogenic mechanisms of CVD, including endothelial dysfunction (EDys), systemic inflammation, oxidative stress, vascular remodeling, and atherothrombosis (Chistiakov et al., 2016). ED is associated with the presence and extent of asymptomatic CVD and is considered to be an early clinical marker for generalized vascular disease (Vlachopoulos et al., 2007). Zadik et al. (2009) first studied the association between these two diseases and proposed that ED and CPD might be two ends of the cardiovascular spectrum. Patients with more severe vasculogenic ED had higher prevalence of CPD, as illustrated by Sharma et al. (2011). A positive correlation between the severity of ED with periodontal pocket depth, attachment loss, and bone loss was also observed (Oğuz et al., 2013; Uppal et al., 2014). Besides, periodontal treatment could provide additional benefits in the improvement of ED (Eltas et al., 2013; Parenti et al., 2015) and dental extraction might overcome the process of ED for CPD patients (Tsao et al., 2015). However, one study conducted by Pournaghash-Tehrani (2015) on 31 coronary heart disease (CHD) patients failed to detect a relationship between CPD and ED). The inconsistent clinical evidence makes the relation of CPD and ED still obscure.

This study aimed to further examine the association between ED and CPD in a Chinese setting through applying the scores of the Community Periodontal Index for Treatment Needs (CPITN) and the International Index of Erectile Function (IIEF).

Method

Sample Selection

This case-control study involved 100 male patients with ED from the Department of Infertility and Sexual Medicine (case group) and 102 male participants with normal erectile function (EF) from the Department of Stomatology (control group) at the Third Affiliated hospital of Sun Yat-Sen University in Guangzhou, Guangdong, China. This study was approved by the Research Ethics Committee of the hospital. An informed consent was obtained from all participants before enrollment.

Subjects were only included if they had a minimum age of 20 years with >20 permanent teeth, had not taken antibiotics or undergone periodontal treatment in the past 6 months prior to the examination, and had had sexual intercourse in the past 4 weeks. Besides, the case group should have disease duration of at least 3 months. The exclusion criteria were as follows: (1) the presence of systemic disease (diabetes mellitus, CVD, etc.); (2) a family history of periodontal disease; (3) aggressive periodontitis; and (4) a history of deformity or trauma of the genital organ. The included subjects were interviewed with regard to sociodemographic information, smoking habits, oral care habits, and self-perceived periodontal health. Patients were diagnosed for ED by an andrologist. One examiner collected the IIEF questionnaire and recorded periodontal parameters.

Periodontal Assessment

The CPITN index was used to record periodontal status and treatment need. The assessments were conducted by one single calibrated examiner. The intra-examiner repeatability was tested through duplicate examinations of 12 individuals.

Periodontal examination was performed under natural illumination, employing flat dental mirrors and specially designed World Health Organization (WHO) periodontal probes (CPITN probes), and following WHO criteria (Organization, 1997). Six sextants were evaluated for each person according to 10 index teeth: 17/16, 11, 26/27, 37/36, 31, 46/47. All the index teeth were probed at six sites per tooth (mesiobuccal, buccal, distobuccal, distolingual, lingual, and mesiolingual) to determine the presence of the following: healthy (code 0), bleeding but no calculus detected (code 1), calculus detected but no deepened pockets (code 2), pockets of 4 or 5 mm (code 3), or pockets ≥ 6 mm. If less than two functional teeth were present, the sextant was defined as edentulous. If the index teeth in a given sextant were missing, all remaining teeth in that sextant were examined. The code of each sextant was assigned according to the highest code recorded at the index teeth. The CPITN score of the individual was recorded as the highest CPITN code given to any sextant in that individual.

ED Assessment

The IIEF questionnaire is a widely used, multidimensional self-report instrument for screening patients with ED (Rosen et al., 2002). Of this questionnaire, 15 items were developed and divided into five domains of sexual function: EF, orgasmic function (OF), sexual desire (SD), intercourse satisfaction (IS), and overall satisfaction (OS). The questions 1 to 5 and question 15 represented EF and were used to determine the presence of ED. Subjects with an EF score higher than 30 were considered to have normal EF

and those who scored lower than or equal to 25 were considered to have ED. Severity of ED was classified into five grades: no ED (EF score = 26–30), mild ED (EF score = 22–25), mild to moderate ED (EF score = 17–21), moderate ED (EF score = 11–16), and severe ED (EF score = 6–10) (Matsumoto et al., 2014; Rosen et al., 1997).

Statistical Analysis

The study population was stratified by age into three groups: 20 to 30 years, 30 to 40 years, and >40 years. The IIEF scores of ED patients were recorded as mild (22–25), mild to moderate (17–21), moderate (11–16), and severe (6–10). Data were analyzed using SPSS Version 20 (PASW statistics; IBM, Armonk, NY, USA). Student's *t* test (normally distributed values) or Wilcoxon's rank-sum test (non-normally distributed values) was performed for bivariate comparisons. Kruskal–Wallis test was used for comparison among groups. Chi-square test was conducted to compare unordered classified data. The Wilcoxon rank-sum and Kruskal–Wallis tests were adopted for ranked data. Spearman's rank-order correlation statistics were utilized as nonparametric alternatives to assess the relationship between the IIEF score and CPITN. As the relative contribution of various independent variables to the occurrence of the dependent variable (IIEF score) was inconclusive in most instances, a logistic regression was performed. Model 1 was a univariate model. Model 2 was adjusted for education level, monthly income, tooth brushing frequency, and gum bleeding when brushing. Model 3 has been adjusted for age, smoking status, tooth brushing time, education level, monthly income, tooth brushing frequency, and gum bleeding when brushing. Intra-examiner reproducibility was calibrated prior to the beginning of the study and was measured according to the Kappa statistic. Differences were deemed statistically significant when $p < .05$.

Results

The outcome of the kappa statistic was 0.8, which indicated the examiner reliability achieved was in the range considered to be good to excellent.

A total of 202 men aged 21 to 47 years (mean age = 32.6 ± 5.7 years) participated in this study, including 100 ED patients (mean age = 33.3 ± 6.0 years) and 102 dental clinic participants (mean age = 31.8 ± 5.3 years). Table 1 presents the basic characteristics of the case and control groups. There were statistically significant differences between the two groups in education levels ($\chi^2 = -6.43, p < .001$), monthly income ($\chi^2 = -2.80, p = .005$), brushing frequency ($\chi^2 = -3.97, p < .001$), and gum bleeding ($\chi^2 = 17.08, p < .001$). Regarding educational level, the proportion of individuals with a university degree in the case group was lower than that in the control group. As for monthly income, the control group earned less than the case

group. Besides, compared with the control group, the case group brushed teeth less frequently. More people in the case group significantly had gum bleeding than those in the control group. Age, smoking status, tooth brushing time, and kinds of oral hygiene appliances and bad breath were not statistically different between the groups.

When considering Community Periodontal Index (CPI) score, none of the subjects scored 0 or 1. Among ED patients, 18 (18.0%) patients had CPI score 2 that indicated the presence of calculus, 70 (70.0%) had CPI score 3 with periodontal pockets of 4 to 5 mm, and 12 (12.0%) had CPI score 4 with periodontal pocket ≥ 6 mm. Of non-ED controls, the percentages of CPI score 2, 3, and 4 were 50%, 48%, and 2%, respectively. The case group significantly got a higher CPI score ($Z = -5.14, p < .001$) and average CPI score ($Z = -4.53, p < .001$) than the control group, suggesting that ED patients had a worse periodontal condition (Table 2). As regards EF, patients with ED had a median EF score of 15, which indicated moderate ED. The EF score was significantly different between patients with and without ED ($Z = -12.45, p < .001$; Table 3).

Table 4 demonstrates the changes in the CPI and EF scores of all the subjects under different age groups. The average CPI score significantly elevated with age ($H = 10.43, p = .005$). The proportion of subjects with ≥ 4 or ≥ 6 mm periodontal pockets increased with age, indicating an aggravation of periodontal destruction. EF scores tended to decrease with age, denoting a decrease of EF. The maximum CPI and EF scores were not statistically significant among different age groups.

To compare the periodontal status of ED patients and to find relationship between the ED and CPD, the subjects were classified into four groups depending on the severity of ED. Of the four groups, 15 subjects had mild ED, 25 had mild to moderate ED, 35 had moderate ED, and 25 had severe ED. Average CPI scores of 2.00, 2.50, 2.50, and 2.67 were recorded for each group in sequence ($p = .024$; Table 5). Results from this comparison indicated that periodontal damage was getting more severe as ED progressed.

Table 6 exhibits the results of logistic regression analyses which explored the association between CPD and ED. Consequently, after adjustment for age, smoking status, tooth brushing time, education level, monthly income, tooth brushing frequency, and gum bleeding, higher CPI score was identified to be associated with a greater risk of ED (odds ratio [OR] = 2.755, 95% confidence interval [CI] = [1.400, 5.423], $p = .003$), suggesting that CPD was positively associated with the odds of ED.

Discussion

In this study, the association between CPD and ED was explored using the IIEF questionnaire and CPITN. Our

Table 1. Basic Characteristics of the Case and Control Groups.

Variable	Case (n = 100)	Control (n = 102)	t/Z/ χ^2	p
Age, years, M \pm SD	33.3 \pm 6.0	31.8 \pm 5.3	1.93	.055
Education level, n (%)				
High school education or less	46 (46.0)	10 (9.8)	-6.43	<.001
Associate's degree	26 (26.0)	17 (16.7)		
Undergraduate degree	22 (22.0)	63 (61.8)		
Graduate degree	6 (6.0)	12 (11.8)		
Monthly income (CNY), n (%)				
<2,000	6 (6.0)	7 (6.9)	-2.80	.005
2,000–3,000	23 (23.0)	5 (4.9)		
>3,000	71 (71.0)	90 (88.2)		
Smoking status, n (%)				
Nonsmoker	56 (56.6)	66 (64.7)	1.75	.417
Former smoker	21 (21.2)	20 (19.6)		
Current smoker	22 (22.2)	16 (15.7)		
Tooth brushing frequency, n (%)				
Twice or more	41 (41.0)	70 (68.6)	-3.97	<.001
Once	58 (58.0)	32 (31.4)		
Not every day	1 (1.0)	0		
Tooth brushing time, n (%)				
30–60 s	30 (30.0)	24 (23.5)	-1.20	.231
1–2 min	55 (55.0)	58 (56.9)		
3 min or more	15 (15.0)	20 (19.6)		
Kinds of oral hygiene appliances, n (%)				
1	81 (81.0)	70 (68.6)	5.88	.117
2	15 (15.0)	25 (24.5)		
3	3 (3.0)	7 (6.9)		
4	1 (1.0)	0		
Bad breath, n (%)				
Yes	22 (22.0)	31 (30.4)	1.84	.175
No	78 (78.0)	71 (69.6)		
Gum bleeding when brushing, n (%)				
Yes	42 (42.0)	16 (15.7)	17.08	<.001
No	58 (58.0)	86 (84.3)		

Note. Case = case group of ED patients; control = control group of non-ED controls; ED = erectile dysfunction.

Table 2. Periodontal Status of the Case and Control Groups.

Variable	Case	Control	Z	p
CPI score, n (%)				
0	0	0	-5.14	<.001
1	0	0		
2	18 (18.0)	51 (50.0)		
3	70 (70.0)	49 (48.0)		
4	12 (12.0)	2 (2.0)		
Average CPI score, M (Q _L , Q _U)	2.5 (2.17, 2.67)	2.0 (1.67, 2.50)	-4.53	<.001

Note. Case = case group of ED patients; control = control group of non-ED controls; ED = erectile dysfunction; M (Q_L, Q_U) = median and quartile.

results were in line with the previous reports (Keller et al., 2012; Matsumoto et al., 2014; Wang et al., 2016; Zadik et al., 2009) and indicated a strong relation between

the extent of CPD and ED as men with ED were more likely to have periodontitis than those with normal EF. An association between the severity of ED and CPD was also

Table 3. EF Score of the Case and Control Groups.

Variable	Case	Control	Z	p
EF score, M (Q _L , Q _U)	15 (11, 19)	29 (28, 30)	-12.45	< .001

Note. Case = case group of ED patients; control = control group of non-ED controls; ED = erectile dysfunction; EF = erectile function; M (Q_L, Q_U) = median and quartile.

Table 4. Changes of CPI and EF Scores With Age.

Variable	CPI score	20–30 years (n = 62)	30–40 years (n = 115)	≥40 years (n = 25)	H	p
Maximum CPI score	Mean rank	54.7	47.1	55.7	4.73	.094
	0	0	0	0		
	1	0	0	0		
	2	24 (38.7)	41 (35.7)	4 (16.0)		
	3	34 (54.8)	67 (58.3)	18 (72.0)		
	4	4 (6.5)	7 (6.1)	3 (12.0)		
Average CPI score, M (Q _L , Q _U)		2.17 (1.67, 2.5)	2.33 (2, 2.67)	2.67 (2.17, 2.83)	10.43	.005
EF score, M (Q _L , Q _U)		25 (15.8, 29)	24 (16, 29)	17 (10, 28)	5.78	.056

Note. CPI = Community Periodontal Index; EF = erectile function; M (Q_L, Q_U) = median and quartile.

Table 5. Periodontal Status of Patients With Varying Degrees of ED.

Variable		Mild (n = 15)	Mild to moderate (n = 25)	Moderate (n = 35)	Severe (n = 25)	H	p
Maximum CPI score	Mean rank	30.0	48.1	55.7	57.9	16.00	.001
	0	0	0	0	0		
	1	0	0	0	0		
	2	8(53.3)	4 (16.0)	2 (5.7)	4 (16.0)		
	3	7 (46.7)	20 (80.0)	29 (82.9)	14 (56.0)		
	4	0	1 (4.0)	4 (11.4)	7 (28.0)		
Average CPI score, M (Q _L , Q _U)		2.00 (1.83, 2.33)	2.50 (2.17, 2.75)	2.50 (2.17, 2.67)	2.67 (2.17, 2.83)	9.43	.024

Note. CPI = Community Periodontal Index; ED = erectile dysfunction; M (Q_L, Q_U) = median and quartile.

Table 6. Logistic Regression Analysis for the Association Between CPD and ED.

Variable	Model 1		Model 2		Model 3	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
CPI score	3.416 (1.967, 5.932)	< .001	2.844 (1.515, 5.342)	.001	2.755 (1.400, 5.423)	.003

Note. Model 1: univariate model. Model 2: adjusted for education level, monthly income, tooth brushing frequency, and gum bleeding when brushing. Model 3: adjusted for age, smoking status, tooth brushing time, education level, monthly income, tooth brushing frequency, and gum bleeding when brushing. CPD = chronic periodontal disease; ED = erectile dysfunction; CPI = Community Periodontal Index; OR = odds ratio; CI = confidence interval.

identified as periodontal damage was increasingly severe with the progress of ED which was in accordance with previous study (Uppal et al., 2014).

The average age of the included men with ED was approximately 33 years. With an increasing incidence of ED among young men, according to China's national conditions and mainly due to inadequate sex education, young

people are more inclined to seek medical help for ED, to improve the quality of life and plan future births, and old people tend to not consider ED a serious disease requiring treatment and are unwilling to go to the hospital just for ED (Li et al., 2012; Nguyen et al., 2017; Pozzi et al., 2020; Shamloul & Ghanem, 2013; Zhang et al., 2014). Moreover, patients with systemic diseases, mostly elderly, were

excluded from the study. Therefore, the ED population included in this study was young, and investigation into the association between CPD and ED in this population may facilitate early management of these two diseases among young adults.

Although psychogenic ED is more common in the younger population, at least 15% to 20% of these men have an organic cause (Papagiannopoulos et al., 2015). Studies have identified an organic cause in 15% to 72% of men with ED younger than 40 years (Ludwig & Phillips, 2014). Based on existing literature and research analysis, there might be three possible mechanisms of the association between CPD and ED, which are systemic inflammation, EDys and atherosclerosis (Zadik et al., 2009). As is well known, CPD is not only associated with a localized increase but also with a low-grade systemic increase in inflammation. Locally released pro-inflammatory mediators by destructed periodontium, such as interleukin-1 (IL-1), tumor necrosis factor- α (TNF- α), and prostaglandin E2 (PGE2), may disseminate into the blood circulation (Assinger et al., 2011; Loos, 2005), which results in a hyper-inflammatory state, inducing increased susceptibility to infections and poor wound healing (Akram et al., 2016). ED has been suggested to be associated with increased subclinical systemic inflammation (Das, 2007). Raised circulating levels of inflammatory compounds, including C-reactive protein (CRP), IL-1 β , and TNF- α , are related to the presence and severity of ED (Blans et al., 2006; Vlachopoulos et al., 2006, 2007). Based on that it is reasonable to presume CPD to be a risk factor for the occurrence and development of ED.

Penile erection and detumescence is a complex neurovascular process modulated by psychological factors and biochemical mediators, in which endothelium plays a critical role by synthesizing and releasing vasoactive substances to maintain vascular tone (Blick et al., 2016). Nitric oxide (NO), which is produced in both cavernosal nerves and endothelium, has been proved to be essential and vital in the physiological regulation of penile erection, and impaired NO activity is important to the pathogenesis of ED (Yavuzgil et al., 2005). Under normal conditions, the initial activation of the endothelium during penile erection process occurs by the stimulation of neurogenic NO. Endothelial-derived NO regulates smooth muscle relaxation and inhibits vascular smooth muscle proliferation (Blick et al., 2016). At the cellular level, EDys leads to impaired synthesis and release of NO, reduced NO bioavailability and accelerated degradation of NO, thereby resulting in weakened sexual function (Blick et al., 2016; Yavuzgil et al., 2005). It is worth noting that a research about NO production in periodontitis patients reports that decreased levels of NO metabolites in serum and saliva are present only in males but not in females. The authors believe that this could be one of

the bases for the association between CPD and ED (Andrukhov et al., 2013). Subjects with periodontal disease exhibit EDys (Amar et al., 2003). Bacteria associated with CPD, such as *Porphyromonas gingivalis* (*P. gingivalis*), may contribute to endothelial activation or dysfunction (Aarabi et al., 2015; Rafferty et al., 2011). Similarly, endotoxemia caused by oral pathogens, such as outer membrane vesicles or gingipains from *P. gingivalis*, or free soluble bacterial components from *Aggregatibacter actinomycetemcomitans*, can induce pro-atherosclerotic responses in endothelial cells. Besides, oral bacteria can also induce EDys through invasion of these cells (Reyes et al., 2013). Periodontal therapy may not only reduce systemic inflammation but also alleviate EDys (Makhene et al., 2016).

The third reason why CPD is linked to ED might be atherosclerosis. Periodontal bacteria and their products are believed to be involved in all stages of atherogenesis according to considerable epidemiological studies, in vitro experiments, animal models and clinical trials (Chistiakov et al., 2016). Periodontal pathogens might be involved as additional risk factors in the pathogenesis of atherosclerotic vascular disease (ASVD; Armingohar et al., 2014; Gaetti-Jardim et al., 2009). Periodontopathic bacteria might directly or indirectly promote atherogenesis via platelet aggregation, enhanced low-density cholesterol and lipoprotein deposition in the artery walls, invasion of cardiac and carotid endothelium, and high levels of inflammatory mediators in the circulation and tissues (Gaetti-Jardim et al., 2009). In addition, higher levels of serum total cholesterol and low-density lipoprotein (LDL) are observed in patients with periodontal disease (Ardila et al., 2015; Katz et al., 2002). Lipopolysaccharide (LPS) from periodontal pathogens can promote atherogenesis via multiple mechanisms that involve serum lipid redistribution toward formation of pro-atherosclerotic lipid profile and cooperation with LDL and very low-density lipoprotein (VLDL) to induce vascular inflammation and lipid accumulation in macrophages (Chistiakov et al., 2016; Cutler et al., 1999). With the occurrence of chronic bacteremia, the adaptive immune system is activated in response. Molecular mimicry is considered to occur when sequence similarities between foreign and self-peptides produce cross-activation of autoreactive T or B cells that can lead to tissue pathology or autoimmunity (Kholy et al., 2015). Heat-shock proteins (HSPs) are known to be the most immunogenic antigens of bacteria (Bartova et al., 2014). Overexpression of HSP on the surface of vascular endothelial cells may be induced by many inflammatory and non-inflammatory stimuli, including exposure to LPS, which could be a potential explanation for the putative relationship between periodontal disease and ASVD (Kholy et al., 2015). These

plausible mechanisms are contributors to the initiation and propagation of atherogenesis.

ED and CVD share the same risk factors, including diabetes mellitus, hypercholesterolemia, hypertension, and smoking. ED can be a warning sign of generalized or focal arterial disease in some men (Banks et al., 2013; Billups, 2005; Dean & Lue, 2005; Thompson et al., 2005). It predicts the presence and extent of subclinical atherosclerosis independent of traditional risk factors for CVD (Chiurlia et al., 2005). This may occur because of different sizes of various vessels. An erection is a vascular event and the penis is a vascular organ, which may be a more sensitive vascular bed to systemic disease because of smaller diameter of the cavernosal arteries than larger vessels (Chiurlia et al., 2005). Atherosclerotic or traumatic arterial occlusive disease of the penile vascular system can decrease the perfusion pressure and arterial flow to the sinusoidal spaces, thus causing inability to maximal engorgement and erection (Dean & Lue, 2005). In addition, the decrease in oxygen tension in the corpus cavernosum blood due to arterial insufficiency may diminish cavernous trabecular smooth muscle content, which could result in diffuse venous leakage (Dean & Lue, 2005). Any injury or toxin that affects the normal functioning of blood vessels anywhere in the body can trigger ED (Kloner & Speakman, 2002). In brief, ASVD might be one of the explanations for the association between CPD and ED.

Additional evidence that provides support for the biological plausibility of the influence of CPD on the progression of ED comes from Zuo et al. They initially conducted experimental studies regarding the effect of periodontitis on ED through induction of periodontitis in rats, and reported that mild systemic inflammatory status in periodontitis significantly decrease not only the expression of endothelial nitric oxide synthase (eNOS), but also the activity of nitric oxide synthase (NOS) in cavernous tissue of rats, which resultantly impaired the function of penile erection (Zuo et al., 2011).

In turn, the authors think that ED may be a risk factor for periodontitis through psychological damage. ED is strongly correlated with emotional states, such as anger and depression, and with attributes of dominance/passivity which might represent underlying susceptibility (Feldman et al., 1994). Men with ED may have a reactive depression as a consequence of a negative reaction from partners related to the sexual dysfunction and psychosocial stress. They may be overly critical of themselves or have the tendency to self-focus. These character traits/behaviors may relate to performance anxiety, erectile ability inhibition, and loss of self-esteem and self-confidence, as well as anger, chronic anxiety, and depression in men with ED (Araujo et al., 1998; Shabsigh et al., 1998; Shiri et al., 2007).

Houri-Haddad et al. (2003) conducted an animal experiment to test the effect of emotional stress on the humoral immune response to the periodontal pathogen *P. gingivalis* by setting up a model of local inflammation, and identified that chronic psychological stress had a marked impact on the localized response to *P. gingivalis* challenge. Relationship between stress and generalized periodontal disease in men has also been reported (Aleksejunienė et al., 2002). Mental health might be associated with the risk of developing periodontal disease. Different psychosocial factors, including depression, stress, anxiety, loneliness, negative life events, daily strain, occupational stress, life satisfaction, and Type A personality and coping behaviors, were all related to periodontitis. Susceptibility to periodontal disease may not be related as much to stress as it is to unhealthy periodontal behaviors that occur when individuals respond to stressors (Aleksejunienė et al., 2002; Chiou et al., 2010). In view of the above, it is reasonable to speculate that psychological symptoms related to ED may adversely influence periodontal health.

There are some limitations in this study. First, selection bias possibly exists due to this case-control study design. Second, the IIEF questionnaire is a self-report questionnaire for ED, which may affect the objectivity of our findings. Third, this research is based on a single center and may not applicable to other populations.

Conclusion

Our study demonstrated an association between ED and chronic periodontitis, emphasizing the importance of regular oral examinations for patients with ED and multidisciplinary approaches for ED treatment. Large-scale studies and longitudinal follow-up should be warranted to further explore the link between these two diseases.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics Approval and Informed Consent Statements

This study was approved by the Research Ethics Committee of the Third Affiliated Hospital of Sun Yat-Sen University. An informed consent was obtained from all participants before enrollment.

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