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Effectiveness of non-surgical periodontal therapy in a large Chinese population with chronic periodontitis

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Abstract

Aim: The aim of this study was to evaluate the effectiveness of non-surgical periodontal treatment (NSPT) and its influential factors in a large Chinese population with chronic periodontitis.

Methods: Periodontal examination data of 10,789 patients with at least one periodontal re-evaluation record were extracted from a hospital-based electronic periodontal charting record system. Probing depth (PD) and bleeding index (BI) reductions after NSPT and their influential factors were analysed by multilevel analysis.

Results: Mean PD reductions at patient level and site level were 0.62 and 0.65 mm respectively. Mean reductions of percentage of tooth with BI > 1 and BI > 2 were 14.9% and 25.21%. Multilevel analysis demonstrated that PD and BI reductions were mainly influenced by baseline PD, baseline attachment loss (AL), baseline mobility, tooth type and frequency of periodontal maintenance (FPM). Besides, PD reduction was associated with baseline BI for all sites and was associated with gender and smoking status for sites with baseline PD ≥ 5 mm.

Conclusion: The effectiveness of NSPT on patients with chronic periodontitis was proved in a large Chinese population. Outcomes of NSPT were mainly influenced by baseline PD, baseline AL, baseline mobility, tooth type and FPM.

Key words: multilevel analysis; non-surgical peridontal therapy; periodontitis; real-world study

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Periodontal diseases are among the most common infective diseases and have association with multiple systemic diseases (Michalowicz et al. 2006, Tonetti et al. 2007, Detert et al. 2010, Cullinan & Seymour 2013, Bokhari et al. 2014, Hasturk & Kantarci 2015, Zhou et al. 2015). It has been widely accepted that dental plaque biofilm is the pathogenic factor of periodontal diseases. The treatment of periodontitis centres on effective control of periodontal inflammation and establishment of a local biologically acceptable environment by non-surgical periodontal therapy (NSPT) or surgical therapy aiming at reconstruction or regeneration of periodontal tissue (Drisko 2001, Heitz-Mayfield 2005, Dentino et al. 2013). In spite of advances in the knowledge of disease pathogenesis and adoption of many new techniques, traditional NSPT to remove bacterial accretions of teeth continues to be an integral part of periodontal therapy (Heitz-Mayfield 2005, Suvan 2005).

Conflict of interest and source of funding statement

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Efficacy is the extent of a beneficial outcome produced by an intervention under controlled ideal circumstances such as clinical trials. Efficacy of NSPT has been proved by many studies (Van der Weijden & Timmerman 2002, Trombelli et al. 2015). Effectiveness, however, focuses on the extent of a beneficial outcome produced by an intervention under practical circumstances (Suvan 2005). A treatment tested by clinical trials may not be effective in the real world since the act of inclusion into a study may be a distortion of the usual practice (Marley 2000). Clinical outcomes of NSPT are often influenced by multiple confounding factors such as age (Trombelli et al. 2010), gender (Mascarenhas et al. 2003), cigarette smoking (Papantonopoulos 1999, Pahkla et al. 2006, Wan et al. 2009), patient compliance (Leininger et al. 2010), etc. Unfortunately, it is unrealistic to evaluate influence of all the factors in randomized control trails (RCTs). It is worth evaluating the synthetic effect of multiple factors that affect the effectiveness of NSPT in clinical practice.

Moreover, existing data of NSPT outcomes are mainly from Caucasian people. Chinese patients have different genetic (Armitage et al. 2000, Deng et al. 2011), microbiological background (Kumar et al. 2005, Griffen et al. 2012, Scher et al. 2012, Bizzarro et al. 2013, Zhou et al. 2013, Li et al. 2015) and periodontal condition (Qi 2008) with patients from European and USA. It is not known whether ethnic differences affect the effectiveness of NSPT.

Therefore, the aim of the present large sample hospital-based retrospective study is to evaluate the effectiveness of NSPT and its influential factors on Chinese chronic periodontitis (CP) patients by data extracted from the data warehouse of the electronic periodontal charting record system (EPCRS) in the Information Center of Peking University Hospital and School of Stomatology. The system was established in 2007 and had collected almost 90,000 records by January 2015 including characteristics and periodontal parameters of patients. The hypothesis of this study is that the change in pocket depth and gingival bleeding status after NSPT was influenced by multiple factors including age, gender, frequency of periodontal maintenance (FPM), smoking, tooth type and clinical parameters before treatment and the effectiveness of NSPT can be proved on Chinese people.

Material and Methods

Study population

Patients who had received NSPT in the Department of Periodontology, Peking University School and Hospital of Stomatology and had at least one periodontal re-evaluation record from January 2007 to January 2015 were included in this retrospective study.

The study was approved by the Ethics Committee of the Peking University School and Hospital of Stomatology (approval number: PKUSSIRB-201310066). All protocols were performed in accordance with approved guidelines and regulations. Informed consent was obtained from all subjects.

Inclusion criteria were as follows:

- Age of 18–80 years;
- Patients diagnosed as CP according to the classification proposed at the International Workshop for the Classification of Periodontal Diseases and Conditions in 1999 (Armitage 1999) and had at least one tooth with a probing depth (PD) ≥4 mm and AL (attachment loss) ≥3 mm;
- Patients with a follow-up of at least 6 weeks.

Exclusion criteria were:

- Systemic disease (e.g. acquired immune deficiency syndrome; diabetes mellitus; nephrosis; hepatopathy; hypertension; neutropenia, etc.), pregnancy or under medication known to affect periodontium;
- Periodontal surgery history.

The process of patients' selection and screening is presented in Fig. 1.

Data extraction

The following patient-related parameters assessed at the initial visit (T0) and the last evaluation (T1) were extracted from the EPCRS for analysis:

Patient level:

- Age;
- FPM (regular – receiving supportive periodontal treatment (SPT) at least once a year *versus* irregular – missing SPT at any year);
- Gender (male *versus* female);
- Observation period calculated by the interval between T0 and T1;
- Smoking status (non-smoker classified as patients who did not smoke at the initial visit, ex-smoker classified as patients who quitted smoking during NSPT and smoker classified as patients who still smoked at the last visit);

Tooth level:

- Mazza bleeding index (BI) values recorded 30 seconds after probing (0–5) (Mazza et al. 1981) (The higher BI between buccal and lingual surfaces of each tooth was recorded as the BI of the tooth);
- Tooth mobility (0–III) (Lang & Lindhe 2015);
- AL measured by the distance from the cementoenamel junction to the bottom of the periodontal pocket (The greatest AL of buccal and lingual surfaces of each tooth was recorded and mean AL of buccal and lingual surfaces was computed);
- Tooth type (molars *versus* non-molars);

Site level:

- PD measured at six sites (mesial, distal and middle sites of buccal and lingual surfaces);

Tooth and site level data from the third molars and teeth lost during NSPT were excluded.

Periodontal examinations and treatments

All periodontal examinations and treatments were performed by qualified clinical periodontists who were systematically trained and calibrated in pre-clinical programs.

NSPT was performed after the initial examination including oral hygiene instruction (OHI), scaling and root planing (SRP) using ultrasonic scalers and hand instruments

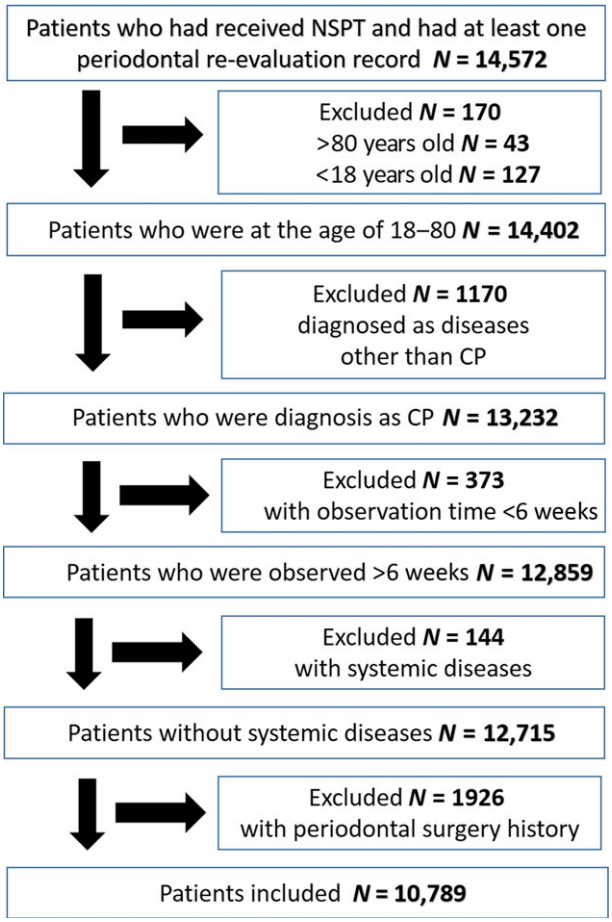

Fig. 1. Flow chart of patients' selection and screening.

for sites with PD ≥ 4 mm. The overwhelming majority of NSPTs were finished within two to four appointments. All patients were asked to re-evaluate at 6 weeks after initial treatment. Full-mouth periodontal charting, OHI reinforcement, prophylaxis scaling and SRP for residual pockets with PD ≥ 4 mm sites were also performed for every re-visit during maintenance phase. Intervals of SPT were set at 3–6 months.

Statistical analysis

The data were extracted from the EPCRS and analysed using IBM SPSS Statistics 20 software (IBM Corp. 2011; Armonk, NY, USA). Frequency distributions of FPM, gender, smoking status as well as mean values of baseline age and observation period were calculated. Mean values of PD, percentage of sites with PD ≥ 5 mm (PD ≥ 5 mm (%)), percentage of teeth with BI ≥ 1 (BI ≥ 1 (%)) and percentage of teeth with BI ≥ 2 (BI ≥ 2 (%)), at T0, T1 and their reductions at patient level were computed. Intra-class comparisons between T0 and T1 were made using paired *t*-tests. Inter-class comparisons of these variables by FPM, gender, smoking status were made by Student's *t*-tests or one-way ANOVA. To explain the hierarchical and clustered structure of periodontal data, multilevel (patient at level 1, tooth at level 2 and site at level 3) analysis was adopted in this study. PD reduction at site level and BI reduction at tooth level were analysed as dependent variables by multilevel linear and logistic regression respectively. Variance Components models with no independent variable included (null model) were constructed initially to investigate the variance of the PD and BI reduction. At different levels, the random effects were assumed to be uncorrelated and followed Gaussian distributions which were tested by the Kolmogorov–Smirnov test. Subsequently, 10 independent variables (introduced in data extraction) were included in the multilevel regression models. The level of significance was set at $p < 0.05$.

Results

Study population

The study population characteristics and patient related factors under study are shown in Table 1.

Changes of clinical parameters at patient level

At patient level, mean PD reduced significantly by 0.62 mm and PD ≥ 5 mm (%) reduced significantly by 15.21% after NSPT. PD and PD ≥ 5 mm (%) changes after treatment are presented in Table 2. Results showed that significantly greater mean reductions of PD and PD ≥ 5 mm (%) were found in patients with regular FPM compared with irregular FPM (0.79 mm

Table 1. Study population characteristics and patient-related factors under study

Category	*N*	%	Mean (SD)	Range
Age at T0 (years)	–	–	45.12 (18.00)	18.00–79.92
FPM				
Regular	7,360	68.22	–	–
Irregular	3,429	31.78	–	–
Gender				
Female	5,595	51.86	–	–
Male	5,194	48.14	–	–
Observation period (years)	–	–	1.35 (1.50)	0.13–7.97
Smoking				
Non-smoker	7,512	69.60	–	–
Ex-smoker	1,407	13.00	–	–
Smoker	1,870	17.33	–	–
Total	10,789	100.00	–	–

FPM, frequency of periodontal maintenance; T0, the initial visit.

Table 2. Changes in probing depth at patient level

Category	T0	T1	Reduction	*p*
PD (mm)				
FPM				
Regular	3.71 (0.84)	2.92 (0.52)	0.79 (0.69)	**< 0.001**
Irregular	3.35 (0.78)	3.09 (0.63)	0.26 (0.74)	**< 0.001**
p	**< 0.001**	**< 0.001**	**< 0.001**	–
Gender				
Female	3.50 (0.79)	2.90 (0.52)	0.60 (0.73)	**< 0.001**
Male	3.70 (0.88)	3.06 (0.59)	0.64 (0.77)	**< 0.001**
p	**< 0.001**	**< 0.001**	**< 0.001**	–
Smoking				
Non-smoker	3.55 (0.81)	2.93 (0.52)	0.62 (0.73)	**< 0.001**
Ex-smoker	3.61 (0.86)	3.03 (0.60)	0.57 (0.79)	**< 0.001**
Smoker	3.78 (0.91)	3.12 (0.64)	0.65 (0.79)	**< 0.001**
p	**< 0.001**	**< 0.001**	**0.010**	–
Total	3.59 (0.84)	2.98 (0.56)	0.62 (0.75)	**< 0.001**
PD ≥ 5 mm (%)				
FPM				
Regular	28.57 (20.99)	9.60 (10.86)	18.97 (17.75)	**< 0.001**
Irregular	20.28 (18.25)	13.14 (13.86)	7.14 (16.54)	**< 0.001**
p	**< 0.001**	**< 0.001**	**< 0.001**	–
Gender				
Female	23.68 (19.34)	9.17 (10.70)	14.51 (17.62)	**<0.001**
Male	28.36 (21.47)	12.39 (13.07)	15.97 (18.82)	**<0.001**
p	**< 0.001**	**< 0.001**	**< 0.001**	–
Smoking				
Non-smoker	24.61 (19.69)	9.62 (10.79)	14.99 (17.58)	**< 0.001**
Ex-smoker	30.68 (22.51)	14.05 (14.67)	16.63 (19.71)	**< 0.001**
Smoker	26.69 (21.18)	12.19 (13.18)	14.49 (19.44)	**< 0.001**
p	**< 0.001**	**< 0.001**	**0.001**	–
Total	25.93 (20.52)	10.72 (12.00)	15.21 (18.22)	**< 0.001**

PD, probing depth; FPM, frequency of periodontal maintenance; T0, the initial visit; T1, the last visit. Data are means and (standard deviations) of PD and percentages of PD ≥ 5 mm sites at T0, T1 and their reductions.
Bold indicates significant p values.

versus 0.26 mm and 18.97% *versus* 7.14%).

Mean BI > 1 (%), which is equal to bleeding on probing (BOP) (%), decreased significantly by 14.91%. Mean BI > 2 (%) reduced significantly by 25.15%. BI > 1 (%) and BI > 2 (%) changes are presented in Table 3. Results showed that significantly greater reductions of mean BI > 1 (%) and BI > 2 (%) were found in patients with regular FPM compared with ones with irregular FPM (18.32% *versus* 7.60% and 30.90% *versus* 14.54%).

Changes of clinical parameters at tooth and site level

A total of 272,311 teeth and 1,633,866 sites were included for analysis of PD reduction between T0 and T1. The overall mean PD reductions for all sites and for sites with baseline PD ≥ 5 mm were 0.645 mm and 1.627 mm respectively (Table 4). After NSPT, percentage of sites with PD < 4 mm was 79.3%. Percentages of BI reduction at tooth level for all teeth and for teeth with baseline PD ≥ 5 mm were 58.71% and 65.33% respectively. After NSPT, percentage of teeth with BI ≤ 1 was 21.9%.

The Variance Components models showed that significant variations existed at all the levels of the multilevel structure. Site level variation contributed the most to the total variation in PD reduction for all sites and sites with PD ≥ 5 mm and patient level variation contributed more to the total variation in BI reduction for all teeth and teeth with baseline PD ≥ 5 mm (Table 4).

To analyse influential factors of the effectiveness of NSPT, multilevel analysis was performed. Ten independent variables were included in the random intercept models (Tables 5 and 6).

Multilevel linear regression analysis of PD reductions for all sites and sites with baseline PD ≥ 5 mm is presented in Table 5. Baseline age, FPM (patient level), baseline AL, baseline mobility, tooth type (tooth level) and baseline PD (site level) were significantly associated with PD reduction for all sites and sites with initial PD ≥ 5 mm. Smokers had significantly less PD reduction than non-smokers and no significant PD reduction difference was found between ex-smokers and non-smokers. Observation period (patient level) and baseline BI were significantly associated with PD reduction for all sites but not for sites with initial PD ≥ 5 mm. Moreover, greater PD reductions were found in baseline BI = 2 (tooth level) than baseline BI = 0 for sites with initial PD ≥ 5 mm. Among all influential factors that statistically significantly associated with the dependent variable, not all of them had effects with clinical significance (coefficient values <0.1). For all sites, PD reduction was mainly influenced by FPM (patient level), baseline attachment loss, baseline mobility, tooth type (tooth level) and baseline PD (site level). For sites with initial PD ≥ 5 mm, PD reduction was mainly influenced by FPM, gender, smoking (patient level), baseline attachment loss, baseline mobility, tooth type (tooth level) and baseline PD (site level). After the inclusion of the 10 variables, the total variances of models were reduced at each level.

Multilevel logistic regression analysis of BI reductions for all teeth and teeth with baseline PD ≥ 5 mm (Table 6). Baseline age, FPM (patient level), baseline AL and baseline PD (tooth level) were significantly associated with BI reductions for all teeth and teeth with baseline PD ≥ 5 mm. Smokers had significantly less BI reduction than non-smokers. And no significant difference of BI reduction was found between ex-smokers and non-smokers. Observation period (patient level) was only significantly associated with BI reduction for teeth with baseline PD ≥ 5 mm. In a word, BI reduction was mainly influenced by FPM (patient level), baseline AL, baseline mobility, tooth type and PD (tooth level).

Table 3. Changes in bleeding index at patient level

Category	T0	T1	Reduction	*p*
BI > 1 (%)				
FPM				
Regular	84.05 (22.44)	65.73 (30.37)	18.32 (27.48)	**< 0.001**
Irregular	77.62 (26.37)	70.02 (29.32)	7.60 (34.03)	**< 0.001**
p	**< 0.001**	**< 0.001**	**< 0.001**	–
Gender				
Female	82.05 (23.85)	66.55 (29.67)	15.50 (29.78)	**< 0.001**
Male	81.96 (24.05)	67.68 (30.56)	14.28 (30.50)	**< 0.001**
p	0.360	0.242	0.721	–
Smoking				
Non-smokerr	83.12 (23.13)	67.69 (29.70)	15.43 (29.85)	**< 0.001**
Ex-smoker	78.73 (25.93)	65.01 (31.86)	13.72 (30.26)	**< 0.001**
Smoker	80.41 (24.98)	66.65 (29.73)	13.76 (31.37)	**< 0.001**
p	**< 0.001**	**< 0.001**	**0.027**	–
Total	82.01 (23.94)	67.09 (30.11)	14.91 (30.13)	**< 0.001**
BI > 2 (%)				
FPM				
Regular	58.72 (30.12)	28.63 (25.68)	30.09 (30.55)	**< 0.001**
Irregular	49.87 (31.39)	35.33 (28.85)	14.54 (36.91)	**< 0.001**
p	**0.001**	**< 0.001**	**< 0.001**	–
Gender				
Female	56.06 (30.79)	30.31 (26.83)	25.75 (33.49)	**< 0.001**
Male	55.74 (30.82)	31.24 (26.99)	24.51 (33.50)	**< 0.001**
p	0.825	0.444	0.579	–
Smoking				
Non-smoker	56.53 (30.42)	30.56 (26.67)	25.97 (33.26)	**< 0.001**
Ex-smoker	53.75 (32.11)	30.89 (27.76)	22.85 (33.57)	**< 0.001**
Smoker	55.46 (30.94)	31.63 (26.99)	23.82 (34.47)	**< 0.001**
p	**0.002**	0.183	**< 0.001**	–
Total	55.91 (30.80)	30.76 (26.91)	25.15 (33.50)	**< 0.001**

BI, bleeding index; T0, the initial visit; FPM, frequency of periodontal maintenance; T1, the last visit. Data are means and (standard deviations) of percentages of BI > 1 and BI > 2 teeth at T0, T1 and their reductions.
Bold indicates significant p values.

Table 4. Variance Components models for treatment outcomes of non-surgical periodontal treatment

	Coefficient	SE	*p*	Coefficient	SE	*p*
PD	All sites			PD ≥ 5 mm at T0		
Intercept	0.645	0.007	**< 0.001**	1.627	0.008	**< 0.001**
Variance						
Patient level	0.588	0.008	**< 0.001**	0.582	0.009	**< 0.001**
Tooth level	0.191	0.001	**< 0.001**	0.302	0.003	**< 0.001**
Site level	1.061	0.002	**< 0.001**	1.218	0.003	**< 0.001**
BI	All teeth			PD ≥ 5 mm at T0		
Intercept	0.687	0.016	**< 0.001**	0.482	0.016	**< 0.001**
Variance						
Patient level	2.171	0.041	**< 0.001**	2.389	0.040	**< 0.001**
Tooth level	1.000	–	–	1.000	–	–

BI, bleeding index; PD, Probing depth.
Bold indicates significant p values.

Discussion

The effectiveness of NSPT on patients with chronic periodontitis was proved by this hospital-based retrospective study in Chinese patients. The overall mean PD reduction at patient level and site level were 0.62 and 0.65 mm respectively. The results are in agreement with a study to investigate the factors predicting non-surgical periodontal treatment responses in 40 Chinese subjects for 1-year period of observation. In that study, the overall mean PD reduction was 0.62, 0.66 and 0.60 mm at 3, 6 and 12 months respectively (Wan et al. 2009). A systematic review to test the clinical efficacy of NSPT also reported the weighted mean PD reduction was 0.64 mm in pockets initially > 5 mm (Van der Weijden & Timmerman 2002). The mean PD reduction for sites with baseline PD ≥ 5 mm was 1.63 mm in this study. The value was higher than that reported by the systematic review.

Increased tendency of gingival bleeding was found in patients of this study. Mean baseline BI > 1 (%), which is equal to BOP (%), of patients was 82.01% and slightly higher than that (73.45%) of Chinese patients of the study carried out in Hong Kong (Wan et al. 2009). However, mean BOP% of patients from this study was much greater than that (26.4–56.56%) of European or American patients (Sculean et al. 2004, Trombelli et al. 2010, Shiloah et al. 2014, Costa et al. 2015, Baelum & Lopez 2016). After NSPT, percentage of sites with PD > 3 mm was about 20%. Percentage of BOP positive sites, however, reached to nearly 80%. High BOP (%) may be due to poor oral hygiene and ethnic characteristics of Chinese patients. It should be noted that the high BOP (%) after treatment did not mean that gingival bleeding of the patients did not get improved. In this study, post-treatment BI reduction was selected as the dependent variable of multilevel logistic models for better identification of bleeding status changes. This is due to the fact that BI (0–5) may better grade severity of gingival inflammation than BOP, which is a dichotomous scale, for a population with more advanced periodontal inflammation, less regular periodontal maintenance and increased tendency of gingival bleeding (Mazza et al. 1981, Cooper et al. 1983). Results of this study showed that the decrease of mean BI > 2 (%) at patient level was over 25%, which was more pronounced than that of BOP (%). Percentages of BI reduction at tooth level for all teeth and for teeth with baseline PD ≥ 5 mm were about 60% and 65%.

The effectiveness of NSPT is mainly influenced by baseline PD, baseline AL, baseline mobility and tooth type. Among these factors, the most influential one is baseline PD at site level. If a patient's baseline PD was to be increased by 1 mm,

Table 5. Multilevel linear regression analysis of PD reductions for all sites and sites with baseline PD ≥ 5 mm

	All sites			PD ≥ 5 mm at T0		
	Coefficient	SE	*p*	Coefficient	SE	*p*
Intercept	−1.109	0.019	**< 0.001**	−0.628	0.035	**< 0.001**
Patient level						
Age at T0	−0.003	0.000	**< 0.001**	−0.005	0.001	**< 0.001**
FPM (irregular *versus* regular)	−0.265	0.014	**< 0.001**	−0.437	0.022	**< 0.001**
Gender (male *versus* female)	−0.056	0.010	**< 0.001**	−0.100	0.015	**< 0.001**
Non-smoker (reference)						
Smoker	−0.064	0.013	**< 0.001**	−0.106	0.019	**< 0.001**
Ex-smoker	−0.011	0.014	0.428	−0.033	0.021	0.124
Observation period	−0.027	0.004	**< 0.001**	−0.003	0.007	0.642
Tooth level						
AL at T0	−0.507	0.002	**< 0.001**	−0.674	0.005	**< 0.001**
Degree 0 of mobility (reference)						
Degree III	−0.229	0.013	**< 0.001**	−0.274	0.021	**< 0.001**
Degree II	−0.092	0.005	**< 0.001**	−0.119	0.009	**< 0.001**
Degree I	0.021	0.003	**< 0.001**	−0.002	0.006	0.770
BI at T0 = 0 (reference)						
BI at T0 = 4	0.097	0.007	**< 0.001**	−0.029	0.020	0.141
BI at T0 = 3	0.094	0.007	**< 0.001**	−0.033	0.020	0.096
BI at T0 = 2	0.100	0.007	**< 0.001**	−0.043	0.021	**0.039**
BI at T0 = 1	0.125	0.008	**< 0.001**	0.005	0.031	0.871
Tooth types (molar versus non-molar)	−0.507	0.002	**< 0.001**	−0.674	0.005	**< 0.001**
Site level						
PD at T0	0.563	0.001	**< 0.001**	0.591	0.002	**< 0.001**
Variance						
Patient level	0.420	0.007	**< 0.001**	0.208	0.003	**< 0.001**
Tooth level	0.233	0.002	**< 0.001**	0.110	0.001	**< 0.001**
Site level	0.925	0.002	**< 0.001**	0.580	0.001	**< 0.001**

BI, bleeding index; FPM, frequency of periodontal maintenance; PD, Probing depth; T0, the initial visit.
Bold indicates significant p values.

according to multilevel linear regression models, PD reductions of sites would have been 0.56 mm and 0.59 mm greater for all sites and sites with baseline PD ≥ 5 mm. Similarly, statistically positive association was also found between baseline PD and final PD in another study (Tomasi et al. 2007). However, analysis of relation between change and initial PD using regression was thought to be problematic by statisticians concerning mathematical coupling and regression to the mean (Tu & Gilthorpe 2007). Therefore, the association between PD at T0 and PD reduction should be interpreted with caution. Nevertheless, we still included the PD into the final multilevel model due to the following reasons: (i) baseline PD was the most remarkable influential factors to the outcomes of NSPT (Tables 5 and 6) and coefficient of the models accords with clinical practice; (ii) variations in PD were better explained after baseline PD were included and the Variance Components models showed that site level variance contributed the majority of the total variance and site level variance greatly reduced after PD at T0 was included. Data suggested that PD at T0 did have a significant influence on the treatment outcomes of NSPT although the reliability of the effect was comprised by the nature of regression.

Molars had been considered as teeth with inferior treatment outcomes and worse prognosis due to anatomic factors (such as presence of furcation, concavities on the root surfaces and cervical enamel projections) and more posterior position in the arches (Heitz-Mayfield et al. 2002, Matthews & Tabesh 2004, Angst et al. 2013). Results from multilevel analysis showed that PD reduction was less in molars than non-molars and were also supported by other studies using multilevel approach (Tomasi et al. 2007, Wan et al. 2009). Multilevel analysis also demonstrated that teeth with severe AL and hypermobility (degree II or III) were associated with inferior treatment outcomes. This indicated that effect of NSPT on questionable or hopeless teeth is limited and surgical intervention or extraction should be recommended to achieve better treatment outcomes.

FPM is another important influential factor of NSPT (Jansson & Hagstrom 2002, Leininger et al. 2010, Lu et al. 2013). In this study, both multilevel analysis at site level and descriptive analysis at patient level showed that significantly greater BI and PD reductions were found in patients with regular FPM. The results demonstrated that good compliance is essential to a successful periodontal treatment. It should be noted that definitions of compliance varied among these studies but similar conclusions were drawn. FPM of the whole-study population is relatively low considering currently limited attention of dental health of Chinese population and access to adequate dental care. Therefore, a less strict definition of regular periodontal maintenance (Lu et al. 2013) was used in this study to stratify the patients' compliance.

Table 6. Multilevel linear regression analysis of BI reductions for all teeth and teeth with baseline PD ≥ 5 mm

	All teeth			PD ≥ 5 mm at T0		
	Coefficient	SE	*p*	Coefficient	SE	*p*
Intercept	−14.192	14.014	0.311	−13.795	25.092	0.582
Patient level						
Age at T0	−0.004	0.001	**0.006**	−0.007	0.001	**< 0.001**
FPM (irregular *versus* regular)	−0.649	0.057	**< 0.001**	−0.707	0.059	**< 0.001**
Gender (male *versus* female)	−0.036	0.039	0.344	−0.056	0.040	0.157
Observation period	0.030	0.018	0.088	0.036	0.018	**0.046**
Non-smoker (reference)						
Smoker	0.180	0.051	**0.000**	0.161	0.052	**0.002**
Ex-smoker	0.065	0.056	0.243	0.050	0.057	0.378
Tooth level						
Attachment loss at T0	−0.066	0.009	**< 0.001**	−0.094	0.011	**< 0.001**
Degree 0 of mobility (reference)						
Degree III	−0.237	0.073	**0.001**	−0.311	0.077	**< 0.001**
Degree II	−0.148	0.030	**< 0.001**	−0.170	0.034	**< 0.001**
Degree I	0.010	0.019	0.608	−0.023	0.024	0.333
BI at T0 = 0 (reference)						
BI at T0 = 4	18.849	14.013	0.179	18.116	25.092	0.470
BI at T0 = 3	17.143	14.013	0.221	16.462	25.092	0.512
BI at T0 = 2	14.923	14.013	0.287	14.423	25.092	0.565
BI at T0 = 1	12.202	14.013	0.384	11.533	25.093	0.646
Tooth types (molar versus non-molar)	−0.493	0.015	**< 0.001**	−0.510	0.017	**< 0.001**
PD at T0	−0.395	0.012	**< 0.001**	−0.270	0.015	**< 0.001**
Variance						
Patient level	3.017	0.052	**< 0.001**	2.729	0.053	**< 0.001**
Tooth level	1.000	–	–	1.000	–	–

BI, bleeding index; FPM, frequency of periodontal maintenance; PD, Probing depth; T0, the initial visit.
Bold indicates significant p values.

Interestingly, differences in PD reduction and BI reduction between smokers and non-smokers were significant but those between ex-smokers and non-smokers were insignificant. The findings were supported by previous studies on influence of tobacco smoking on development of periodontal disease (Bergstrom 2004, Do et al. 2008). These results suggested that, for current smokers, smoking cessation support should be provided by dental professionals to improve treatment outcomes of NSPT.

Many studies had demonstrated that Caucasian and Asian people are different in many aspects. For instances, studies of bacterial profiles in CP patients by 16S pyrosequencing showed that the relative abundance of *Porphyromonas gingivalis* in Chinese population (there should be a space) (17.85% and 11.26%) (Zhou et al. 2013, Li et al. 2015) was much higher than population from Europe and USA (range from 0.2% to 6%) (Kumar et al. 2005, Griffen et al. 2012, Scher et al. 2012, Bizzarro et al. 2013). When it comes to genetics, genotype frequencies of polymorphisms in vitamin D receptor gene (Deng et al. 2011), IL-1A and IL-1B (Armitage et al. 2000) in Chinese were dramatically different from those in Caucasians.

Furthermore, the prevalence of periodontal diseases in China, especially the advanced periodontal ones, is much higher than developed countries. According to data from the latest National Oral Health Survey of China carried out in 2005, percentages of periodontally healthy people of 35–44 and 65–74 age groups were only 14.5% and 14.1%, respectively, and the prevalence of gum bleeding reached 77.3% and 68%, respectively, for the two age groups (Qi 2008). In this study, 88% of the patients included were classified as advanced periodontitis according to the CDC/AAP case definition (Eke & Genco 2007, Eke et al. 2012). Nevertheless, mean of annual dental visits of citizens in Beijing, one of the most developed cities in China, was only 0.34 per year although the situation was improving over time (Meng 2008). Therefore, multilevel models of this study are more suitable for analysing the effectiveness of NSPT in Asians and/or populations with advanced chronic periodontitis compared with models based on Caucasian populations.

RCTs can only answer narrow questions and focus on efficacy under ideal conditions by maximizing internal validity at the expense of external validity. Real world studies, unlike RCTs with strict inclusion criteria, usually include a number of more heterogeneous samples and provide realistic pictures of routine clinical practice (Michelson et al. 2013). This pragmatic effectiveness study conducted in individuals of huge heterogeneity can provide further complement data for RCTs and other observational studies. Results of this study can reflect the real-world situation due to the following reasons. There are no specific prerequisites for a patient to attend our department (If a patient wants to get periodontal examinations or treatments, he or she can get a registration or an appointment. Our department received patients with all

kinds of periodontal diseases with different severity). In addition, hospital-based data were collected to yield a large sample size to test the effectiveness of NSPT under clinical circumstances. Nearly all accessible data of candidate patients were analysed. However, the study also shares limitations of observational and retrospective studies. Differences in characteristics of the population and confounding factors may lead to bias and threaten the validity of the treatment outcomes (Concato 2012). In addition, systemic diseases such as diabetes mellitus or pregnancy are other factors influencing outcomes of NSPT owing to the effects of periodontal damage and wound healing of diseases themselves and their medication. But systemically compromised patients were not included in the analysis as a result of inaccessibility of detail information of systemic diseases in EPCRS.

Conclusion

The effectiveness of NSPT was proved by this hospital-based retrospective study in a large Chinese population with chronic periodontitis. The outcomes of NSPT are mainly influenced by baseline PD, baseline AL, baseline mobility, tooth type and FPM.

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Clinical Relevance

Scientific rationale for the study: Chinese have different genetic susceptibility to chronic periodontitis (CP), microbiological characteristics and severity of periodontal destruction with Caucasian. It remains unclear whether non-surgical periodontal treatment (NSPT) is also effective and what its influential factors are in Chinese patients.
Principal findings: Effectiveness of NSPT in Chinese CP patients was proved by multilevel analysis. It was mainly influenced by baseline probing depth, baseline attachment loss, baseline mobility, tooth type and frequency of periodontal maintenance.
Practical implications: NSPT is also effective in severe CP patients. Good compliance is essential to treatment success. Non-molars response better than molars. Effect of NSPT on questionable teeth is limited and surgical intervention or extraction is recommended.