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A Relationship between Tooth Loss and Periodontal Disease with Increased Blood Pressure in Adults: A Population-Based Study in Iran.

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ABSTRACT

High blood pressure is one of the major causes of death in developing countries. Studies showed that periodontal disease and tooth loss are independently associated with hypertension. We aimed to investigate the relationship between tooth loss and periodontal disease with hypertension in adults. The population-based cross-sectional study was done on 700 adults in Zahedan(location N: 29° 29' 47'', E: 60° 50' 58'') during years 2013 to 2014. The participants were referred to medical health care centers for measuring their blood pressure, body mass index (BMI) and evaluating their periodontal status. Blood pressure, BMI and evaluating their periodontal were recorded through interview. SPSS software, version 20 was used for entering the data, and multivariate linear regression with 95% confidence intervals was used for the data analysis in order to modulate the effect of confounding variables. After comparison of confounding factors, the average values for systolic and diastolic blood pressure of edentulous participants were obtained 8.02 and 6.64 mmHg (95% CI) respectively, higher than those who had ≥10 teeth in both arches. Total edentulism was in relation to increasing levels of systolic and diastolic pressure in the adult population.
Keywords: tooth loss, periodontal, blood pressure, population.

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INTRODUCTION

High Blood Pressure or hypertension is a serious global health problem that defined as the systolic / diastolic blood pressure higher than 140/90 at rest (1). High blood pressure is the main cause of death in developing countries [2] and a major cause of cardiovascular disease (CVD) and cerebrovascular accident (CVA) so that 54% ischemic heart disease and 47% of CVA are attributed to high blood pressure [2]. Almost, one billion individuals are suffering from hypertension worldwide [3]. Hypertension is a multi-factorial disease. Studies have been shown that apart from known risk factors such as obesity, lack of physical activity and smoking[4-6], oral inflammation such as periodontal disease and tooth loss are also independently associated with increased rate of blood pressure [6-9] and CVA [10 -11].

Tooth loss is a process in which one or more teeth become loose and fall out. One third of US elders are suffering from tooth loss [12].The prevalence of tooth loss in Iranians adults over 65 years has been reported to be 70/7%[13]. With regards to previous studies, age, sex, systemic diseases such as diabetes mellitus, social and geographical disparities and patient and dentist's attitudes towards oral health status, are among the risk factors of leading to tooth loss[13].

A study has reported an inverse association between the number of teeth and increased systolic blood pressure among men [14], while, in another study showed the relationship between tooth loss and increased diastolic blood pressure in women [15].

We aimed to investigate the association between tooth loss and hypertension in adults after measurement for confounding factors in a sample of Iranian individuals.

MATERIALS AND METHODS

Study population

This population-based cross-sectional study was done on 700 adults in Zahedan, southeastern Iran**,** (location N: 29° 29' 47'', E: 60° 50' 58''**)**, from November 2013 to July 2014. The population of the study consists of all adults residing in Zahedan.

Sampling procedure

The sample size was calculated to be 645(Considering α =0.05 and prevalence = 0/3 and (design effect [de]= 2). 700 individuals were enrolled for the present study. Sampling was done using multi-stage random sampling method.

Initially, among 40 medical centers in Zahedan, 10 medical centers were randomly selected from the north, south, east, west and central urban areas (2 from each region). Since 500 families were resided around each health center, after selecting the health centers, the first family was selected randomly around each center, then for collecting the sample size, we moved rightward and the sampling process was done on neighboring families. 70individuals were enrolled from around each selected health center and finally, the required sample size was obtained during the study period.

Inclusion and exclusion criteria

All subjects were over 35 years old and willing to participate in the study. Subjects with amputated hands or feet, those using plasters, those who could / should not get out of bed or be positioned for measurements, or did not complete the information form were excluded from the study. Anthropometric and blood pressure measurements were not recorded for pregnant women and women who have been held for less than 6 months postpartum.

Assessment of tooth loss, blood pressure and periodontal disease status

In order to complete information forms, data were collected by two senior dental students through face-to-face interviews that were under periodontitis' supervision. Students went from home to home and

asked the families to refer to the nearest health center(after obtaining the written inform consent), on a special date for periodontal examination. Periodontal chart was completed for each person by one examiner. Subsequently, participants were categorized in four groups: periodontitis, gingivitis, healthy, complete edentulism.

Blood pressure was measured by a sphygmomanometer and Stethoscope (Riechter, Germany). Measurements were obtained twice with a 10-minute interval. During measurement, the participants were seated with their feet placed completely on the ground. The participants were advised to sit calmly and not to smoke 30 minutes before measuring their blood pressure[6]. The selective arm for measuring blood pressure should not have an arteriovenus fistula for hemodialysis. The brachial pulse of the selected arm was touched to check its suitability for measurement. The arm was placed next to the body a little upper than his waist as the brachial artery was in front of the heart. The lower edge of the cuff was placedabout2.5cmabove the antecubital fossa. The cuff was tightened and the elbow slightly bent. Then the bell of the stethoscope was placed gently over the brachial artery. The cuff was inflated up to 30mmHgmore than the pressure at which the radial pulse was cut off. Then, it was deflated in 2-3secondsandblood pressure was recorded. This was repeated after 10 minutes. Finally, the mean recorded blood pressure in both measurements was calculated and included in the study as blood pressure of each person.

The number of natural teeth in both jaws was counted for each person. Third molar teeth were not included in this study, as they might be impacted or congenitally missed. Therefore, people with zero to 28 teeth were grouped as follows:1-more than 10($\geq$10) teeth in both arches 2-less than10teethat least in one arch 3-edentolus.

Assessment of potential confounders

To identify related confounding factors, age, education, smoking per day, systemic disease such as cardiovascular disease, renal disease, diabetes mellitus and respiratory disease and Body Mass Index(BMI) were also investigated. Participants with cardiovascular disease were excluded from the study. Except BMI, all other mentioned confounding factors were self-reported.for measuring the participants BMI, their height was initially measured by a 2m stature meter vertically installed on the wall while the participant was standing straightly, head forward with their feet placed together. The participants' weight was determined by a German beurer digital scale(ps07, person enwaage). Therefore, the BMI index was calculated using the weight(kg)/height(m^2) formula. The Classification of this index has been defined by the World Health Organization (WHO) as follows [16]:

1-Thin BMI <18.5
2-Normal BMI = 18.5 - 24.9
3-Overweight BMI = 25.0 - 29.9
4-Obese BMI> = 30

The participants were categorized into five groups with respect to smoking: 1- nonsmokers 2-Those who were previously smoking, but not currently smoking(smoking history) 3-Thosewho currently have less than10cigarettesper day(low consumption) 4-Thosewho currently have between10-20cigarettesper day(average consumption) 5-Those who currently have more than20 cigarettes(high consumption)[9].

Data analysis

All Data were assessed by spss software, version 20 and multivariable linear regression test was used for data analysis.

Ethical issues

This study was approved by Zahedan University of Medical Science ethical committee.

RESULTS

Descriptive Statistics

In this study, 700 individuals aged over 35 years were randomly selected from different areas of Zahedan. Tables 1 and 2 show the demographic characteristics of the participants.(refer to the appendix)

The relationship between tooth loss, age, gender, education, BMI, smoking status, diabetes mellitus, periodontal condition, respirator and renal disease with systolic blood pressure were assessed using univariate regression model. There was no statistically-significant relationship between respiratory disease and renal disease with systolic blood pressure. In the next stage, stepwise multivariate linear regression analysis was used and all the above mentioned variables, that were significant in univariate regression, were entered simultaneously into stepwise multivariable linear regression models. Finally, four variables including tooth loss, age, periodontal diseases and body mass index remained in the final model.

The results indicated that the overall model was statistically significant(f=58.06, p<0.001).

A positive and significant correlation was also observed between tooth loss and systolic blood pressure(Table 3).(refer to the appendix)

As described in the Method section, tooth loss Variable was classified into 3 groups: 1-Morethan10(≥10)teeth in botharches2-Less than10teethat least in one arch, 3-edentulous. We found that per each unit of change in tooth loss (from group 1 to 2 and 2 to 3), systolic blood pressure increased by 4.01 mmHg(p = 0.004, Table 3). Therefore, it can be concluded that the systolic pressure in those people who have more than 10 teeth in both arches is 8.02 mmHg higher than edentulous people.

The results of Table 3also indicate that per unit change in age(one year increase), systolic blood pressure increased 0.28 mmHg (p = 0.003).

Moreover, also it has been also found that per unit change in BMI (from class 1 to 4, i.e. 1- is skinny, 2-normal, 3-overweight 4-obese),systolic blood pressure increased significantly by 4.51 mmHg (p <0.001, Table 3).

Periodontal disease was one of the remaining variables in the final regression model. As mentioned, periodontal disease was classified into four categories: healthy, gingivitis, periodontitis and edentulous. According to Table 3, per unit change in periodontal disease from Class 1 to Class 4, systolic blood pressure increased 4.95 mm Hg (p <0.001).

Goodness of fit for this model (adjusted R square) was 0.246, which means that 25% change in systolic blood pressure depends on variables such as tooth loss, age, BMI and periodontal disease.

The association between tooth loss and diastolic blood pressure was initially determined by univariable regression. There was no significant relationship observed between renal and respiratory diseases with diastolic blood pressure. Then, stepwise multivariate linear regression analysis was used and all the variables that were significant in univariate regression were entered simultaneously into stepwise multivariable linear regression models. Finally, three variables including tooth loss, periodontal disease and BMI remained in the final model.

The results indicated that the overall model was statistically significant(f = 26.41, p <0.001).

According to Table 4, a positive and significant correlation between tooth loss and diastolic blood pressure was observed. As shown in Table 4, per each unit change in tooth loss (diastolic pressure increased 3.32 mm Hg (p = 0.002). Hence, it can be concluded that the diastolic pressure of people who are edentulousis 6.64 mm Hg higher than subjects with more than 10 teeth in both arches.

The findings also indicated that per each unit change in BMI(from class 1 to 4),diastolic blood pressure increased 1.43 mm Hg (p = 0.05).

Table 1-4: General characteristics of the studied adult population

		N	Percentage
Gender	Male	327	46.7
	Female	373	53.3
Educational level (years)	≤5	288	41.14
	6-8	150	21.43
	9-11	155	22.14
	≥12	107	15.29
Smoking	Never	437	62.4
	Former	30	4.3
	Light	158	22.6
	Moderate/heavy	75	10.7
Body mass index	18.5>	39	5.57
	18.5-24.9	407	58.14
	25-29.9	245	35.0
	≥30	9	1.29
Hypertension	Normal	278	39.72
	Prehypertension	306	43.71
	Hypertension stage 1	98	14.0
	Hypertension stage 2	18	2.57
Periodontal condition	Periodontitis	321	45.86
	Gingivitis	217	31.0
	Healthy	144	20.57
	Edentulous	18	2.57
Renal disease	No	691	98.7
	Yes	9	1.3
Respiratory disease	No	664	94.86
	Yes	36	5.14
Diabetes	No	629	89.86
	Yes	71	10.14
Tooth loss	Edentulous	18	2.57
	10> Teeth in at least on arch	151	21.57
	≥10 teeth in both arches	531	75.86
Diastolic pressure	<90	636	90.85
	≥90	64	9.14
Systolic pressure	<140	585	83.57
	≥140	115	16.43

Table 2-4: central and dispersion characteristics of the studied subjects by age

	N	Minimum	Maximum	Mean	Sd
Age	700	35	65	45.62	7.4
Systolic pressure	700	100	185	123.62	14.71
Diastolic pressure	700	50	110	73.71	11.52

Table 3-4: the relationship between tooth loss and systolic blood pressure, multivariable linear regression models

Model	Unstandardized Coefficients		Standardized Coefficients	t	sig
	B(95%)CI	Std.error	Beta		
Tooth loss	4.01	1.40	0.11	2.86	0.004
Periodontal disease	4.95	0.82	0.26	5.99	<0.001
Age	0.28	0.09	0.14	2.93	0.003
BMI	4.51	0.85	0.17	5.27	<0.001

B: regression coefficient, 95% CI = 95% confidence interval. Dependent variable: systolic blood pressure.
BMI: body mass index

Table 4-4: the relationship between tooth loss and diastolic blood pressure , multivariable linear regression models

Model	Unstandardized Coefficients		Standardized Coefficients	t	sig
	B(95%)CI	Std.error	Beta		
Tooth loss	3.32	1.09	0.12	3.05	0.002
Periodontal disease	3.30	0.60	0.22	5.49	<0.001
BMI	1.43	0.73	0.07	1.95	0.05

B: regression coefficient, 95% CI = 95% confidence interval. Dependent variable: diastolic blood pressure. BMI: body mass index

In addition, per unit change in periodontal disease (from Class 1 to Class 4), diastolic blood pressure was increased 3.03 mm Hg (p <0.001). The fitness of the model (adjusted R square) was 0.098, which means that 9% change in diastolic blood pressure depends on three variables, namely tooth loss, periodontal disease, and body mass index.

DISCUSSION AND CONCLUSION

The rate of mortality and morbidity caused by ischemic cardiac disease and CVA doubles per each 20 and 10 mmHg increased in systolic and diastolic blood pressure[3]. The present study indicates that systolic and diastolic blood pressure of edentulous subjects were8.02 and 6.64 mm Hg respectively higher than those with more than 10 teeth in both arches. Our obtained results are consistent with another study in South Africa that found systolic and diastolic blood pressure of edentulous subjects were 12 and 5 mmHg respectively higher than those who have all their teeth(P <0.001). In addition, in the mentioned study, blood pressure was defined as systolic / diastolic blood pressure of ≥160/95 mmHg . However, in our study based on the definition of the International Committee on prevention, Detection, evaluation and treatment of hypertension(JNC7), high blood pressure is considered as systolic/diastolic blood pressure of ≥140/90 mmHg and in JNC 8 that published in 2014, this definition has not been changed. Another study, found that tooth loss is considerably associated with systolic blood pressure while there is no significant relationship between tooth loss and diastolic blood pressure[14]. The different obtained results may be attributed to the cultural and ethnic diversity. Also the mentioned study was a retrospective cohort while ours was a cross-sectional one.

Peres and colleagues included white, black and Indian races in their study [12] ; while in our study all participants were of the Asian race. As previous studies showed the risk of hypertension in the black race is higher than other races[18].

In another study on 98 postmenopausal Japanese women, the researcher found that postmenopausal women who had lost some of their teeth, had significantly higher diastolic blood pressure than postmenopausal women who had all their teeth (p=0.021)[15].In the mentioned study[15], tooth loss and an increase in systolic blood pressure were not significantly associated. These differences could be related to different sample population. This study was done on the subset of women with certain age limitation but our study was population-based. Also variables such as smoking, renal disease and diabetes were considered as the exclusion criteria in the mentioned study, while we considered these factors as confounding variables.

After controlling for confounding factors, we found that periodontal disease was significantly related with systolic and diastolic blood pressure; so that systolic and diastolic blood pressure in people with periodontal disease were 9.9 and 6.6 mmHg more than those who were periodontally healthy. Our results were consistent with previous studies [4,6]. Moreover, Nesse and coworkers also found that the prevalence of hypertension in patients with periodontal disease was two times higher than periodontally healthy subjects [19]. Inconsistently, in a 20 years follow-up study, researchers found no association between periodontal disease and hypertension [20].

These contradictory results could have several causes. Due to the cross-sectional nature of the study as compared to the cohort design of the mentioned study, we could not prove a causal relationship between variables. Also, in the mentioned study, data regarding periodontal disease was gathered through self-reports; while the diagnosis of periodontal conditions in our study were done by dentists at health centers. Lastly the

previous study was done on middle-aged educated men (dentists, pharmacists, optometrists, veterinarians, etc.).The educations of our participants were illiterate to university graduates. However after multivariate regression analysis, education and hypertension were not significantly related.

The hypothesis behind the relationship between tooth loss and risk of CVD is related to infection and inflammation causing by oral microorganisms. In a study has been showed Periodontitis as a major cause of tooth loss in adults is a chronic bacterial infection that causes endothelial dysfunction and the carotid artery plaque formation[21]. The subsequent tooth loss resulting from chronic periodontal diseases such as periodontitis, leads to elevated inflammatory markers of blood such as C-reactive protein (CRP) and Plasminogen activator inhibitor 1 (PAI-1) [22]. CRP is a systemic inflammation marker and an acute reactor excreted in response to inflammatory stimuli, including trauma, infection and hypoxia [22]. Researchers found that enhancement of CRP level led to increased blood pressure. High levels of CRP led to vasoconstriction and increased production of endothelin-1 by reducing nitric oxide products in endothelial cells [23].

The relationship between tooth loss and hypertension has highlighted the importance of oral diseases prevention. As it has been found by another study, a decrease in systolic pressure by 20 mmHg leads to a 26% reduction in mortality rates, or in another words, save the lives of 56,479 patients with hypertension[24].

People lose their teeth due to various reasons. Primary teeth may be lost due to orthodontic reasons or dental caries. In our study, we assumed that in older adults periodontal disease was responsible for complete edentulism as supported from previous study [25].

Since periodontal diseases are preventable and treatable, its severe complications such as tooth loss can be avoided. Our results as well as the results obtained by other studies found the relationship between tooth loss and high blood pressure, imply that by increasing the level of social awareness and follow-ups of periodontal treatment, systemic chronic disease such as hypertension can be prevented.

Our study had some limitations. This study was cross-sectional and we suggest cohort studies with long intervals to be done in this regard. Because of the long-term follow-up in cohort studies they may be appropriate to investigate the causes of tooth loss in order to obtain more reliable results. In our study, the incidence of disease, that affect blood pressure (such as renal, respiratory and cardiovascular disease and diabetes) were recorded as self-reports. Due to the high number of participants, lack of patient compliance and high costs we did not perform examination to confirm their reports. We recommended that the incidence of these diseases be investigated using clinical examination and trials in future studies.

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