

ORIGINAL ARTICLE

Periodontal conditions in vegetarians: a clinical study

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BACKGROUND/OBJECTIVES: Investigations about possible correlations between vegetarian diet and periodontal conditions are rare and characterized by small case numbers. The aim of this clinical study was to investigate the influence of a vegetarian diet on periodontal parameters with an appropriate sample size.

SUBJECTS/METHODS: A total of 200 patients, 100 vegetarians and 100 non-vegetarians, were included in the study. All patients were examined including a full mouth assessment of the periodontal and dental conditions. In addition, a questionnaire was handed out to ask for patients' oral hygiene habits and level of education. For statistical analysis the Mann–Whitney Test (χ^2 for analysis of the questionnaire) was applied (level of significance: $P < 0.05$).

RESULTS: Well known periodontal risk factors like age, gender and smoking habits were equally distributed within each group (71 females, 29 males, respectively and 10 smokers in each group; mean age: 41.45 years vegetarians versus 41.72 years non-vegetarians). Vegetarians had significantly lower probing pocket depths ($P = 0.039$), bleeding on probing ($P = 0.001$), periodontal screening index ($P = 0.012$), a better hygiene index ($P < 0.001$) and less mobile teeth ($P = 0.013$). Dental examinations revealed significantly less missing teeth ($P = 0.018$) but also more decayed ($P = 0.001$) and eroded ($P = 0.026$) teeth in vegetarians. Furthermore, vegetarians had a higher level of education ($P < 0.001$), but visited dentists significantly less frequent.

CONCLUSIONS: Vegetarians revealed better periodontal conditions (less inflammation signs, less periodontal damage and a better dental home care). However, it should be considered that vegetarians are not only avoiding meat in their nutrition but are also characterized by an overall healthier life style.

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INTRODUCTION

Gingivitis and periodontitis are chronic inflammatory diseases of the tooth supporting tissues (periodontium) due to bacterial infection. The bacterial biofilm that is firmly attached to the teeth's surfaces cause a chronic inflammation, which may vary between a slight and reversible gingivitis and a severe irreversible periodontitis that may finally result in tooth loss.¹ Periodontitis is considered to be one of the two most important global oral health burdens.² Gingivitis and periodontitis are primarily local diseases but can also cause systemic inflammation.³ As two decades there is an increase of investigations proving a correlation between periodontitis and systemic diseases like diabetes mellitus,^{4,5} adverse pregnancy outcome,⁶ osteoporosis,⁷ rheumatoid arthritis,⁸ pneumonia,⁹ chronic obstructive pulmonary disease¹⁰ and cardio- and cerebrovascular disease.^{6,11}

The effects between periodontitis and most of the above mentioned diseases are mutual.^{4,6,8} Considering the etiology of gingivitis and periodontitis, the bacterial biofilm is the primary risk factor. However, they are more secondary and so named alterable (patient-specific) risk factors like smoking, stress, diabetes mellitus, compliance, socio-economic factors and food habits.¹² Hence, gingivitis and periodontitis are multi-factorial diseases.

Regarding the association between nutrition and periodontitis, an increasing amount of data has been published over the last 10 years. These investigations focus on the correlation between periodontitis on the one hand and obesity, fermentable carbohydrates and antioxidants on the other hand. Obese individuals show an increased local inflammatory response characterized by

elevated levels of acute phase proteins, proinflammatory cytokines (for example interleukin-6), leukocyte counts and an affected T cell function.^{13,14} Therefore, obese individuals reveal more severe forms of periodontitis more frequently.¹⁵ Obesity is a marker for excessive fermentable carbohydrate intake. The supply of fermentable carbohydrates directly results in increasing plaque accumulation. Indirectly, increasing levels of glycated hemoglobin lead to a higher degree of periodontal inflammation signs and, thus, more damage of periodontal tissues.¹⁶ Antioxidants like vitamin C has a central role in defending from free radicals, improve chemotaxis and phagocytosis of polymorphonuclear leukocytes, and improve lymphocyte responsiveness. Several studies investigating the relationship between vitamin C intake and the severity of periodontitis proved a protective effect of vitamin C on periodontal tissues.^{17,18}

What are the characteristics of a vegetarian diet? Generally, the word 'vegetarianism' is used for a special form of nutrition, which is characterized by avoiding meat supply. Beyond that, vegetarians consume a higher amount of antioxidants in form of fruits and vegetables and less quantities of fermentable carbohydrates.¹⁹ In addition, vegetarianism is mostly a specific attitude of life, which is characterized by above-average health behavior. Several studies revealed less tobacco and alcohol consumption, more physical activity and a lower body mass index (BMI) among vegetarians.^{20–22} However, diseases like depression, tiredness, headaches and menstrual irregularity are more frequently observed in vegetarians.^{21,23} The prevalence of widespread diseases like cardiovascular diseases, stroke and several

malignant tumors is lower in vegetarians compared with non-vegetarians.^{24,25}

Only scarce data are available in the medical and dental literature concerning the oral health in vegetarians. Several studies documented a positive influence of a vegetarian diet on dental conditions. Thus, vegetarians showed a lower prevalence of caries.²⁶ Investigations about possible correlations between a vegetarian diet and periodontal conditions are rare and characterized by small case numbers. In addition, the assessment of periodontal conditions was inadequate in various studies.

The aim of this clinical study was to investigate the influence of a vegetarian diet on periodontal parameters with an adequate periodontal examination and an appropriate sample size. The hypothesis that was set forth was that a vegetarian diet may improve periodontal conditions.

MATERIALS AND METHODS

In accordance with the Declaration of Helsinki, the present study was approved by the Ethical Committee of Hannover Medical School (No. 4094). The study was designed as a prospective and controlled clinical trial.

Participants

A total of 200 patients, 100 vegetarians and 100 non-vegetarians, were included in the study. Participants were selected according to the following inclusion criteria: (1) majority, (2) at least 10 teeth, (3) vegetarian diet for more than 2 years for subjects in the vegetarian group.

Exclusion criteria were: (1) systemic diseases that negatively influence periodontal conditions (for example, diabetes mellitus or infection diseases like HIV-infection), (2) pregnancy or breastfeeding, (3) history of drug abuse.

Both groups were matched concerning well known periodontal risk factors like age, gender and smoking habits.

Detailed instructions were given to the participants including an information brochure explaining the study design. All subjects signed an informed consent form.

Periodontal examination

All patients underwent once a comprehensive periodontal examination, including probing pocket depth (PPD), gingival recession (GR), clinical attachment level (CAL) and bleeding on probing (BOP) assessed at six sites per tooth (disto-buccal, buccal, mesio-buccal, mesio-oral, oral, disto-oral). All measurements were carried out under the same conditions by two calibrated investigators using the WHO periodontal probe to ensure consistency of measurements. Depending on PPDs, the Periodontal Screening Index (PSI)²⁷ was determined. The degree of tooth mobility²⁸ and for multi-rooted teeth the degree of furcation involvement²⁹ was documented. Additionally, bacterial plaque accumulation was assessed using a hygiene index (HI).³⁰ On the basis of the mucogingival morphology, patients were divided in two groups: (1) thick gingival biotype and (2) thin gingival biotype. The thick gingival biotype was defined as being present when the gingiva showed evident keratinization and a thickness of 1.5 mm, and the thin gingival biotype when the gingiva had a slight keratinization and a thickness of <1.5 mm.³¹ Detailed information about the clinical parameters is given in Table 1.

Dental examination

A dental examination was performed in all patients recording fillings, caries, crowns and missing teeth. The index for decayed, missing and filled teeth and surfaces, respectively (DMF-T, DMF-S),³² were determined. DMF-T was subdivided in decayed teeth (DT), missing teeth (MT) and filled teeth (FT). Additionally, the number of eroded teeth was documented.

Questionnaire

A questionnaire was handed out to ask for patients' oral hygiene habits, frequency of dentist visit, the level of education and the duration of vegetarian diet for subjects in the vegetarian group.

Statistical analysis

The calculation of the sample size was carried out using nQuery Advisor 6.0 (Statistical Solutions, Saugas, MA, USA). The analysis showed that a sample size of 100 had a power of 80%. The recorded data were documented and analysed by the data procession program SPSS 17.0 for Windows (SPSS, Chicago, IL, USA). Each individual subject counted as a statistical unit of all tests. Mean and range values were calculated for all parameters. The Mann-Whitney test was applied to determine significant differences

Table 1. Definition of all assessed periodontal parameters

Parameter	Definition
PPD	Distance between the marginal gingiva and the bottom of the periodontal sulcus, expressed in mm
GR	Distance between the enamel-cementum-junction and the marginal gingiva, expressed in mm
CAL	Sum of PPD and gingival recession
PSI	Assessed for each sextant and divided into the following five codes: Code 0 = PPD < 3.5 mm, no calculus, no defect restorations, no BOP Code 1 = similar to Code 0, but positive BOP (gingivitis) Code 2 = similar to code 1, but also calculus or defect restorations (gingivitis) Code 3 = PPD between 3.5 mm and 5.5 mm (periodontitis) Code 4 = PPD > 5.5 mm (severe periodontitis)
Degree of furcation involvement	Assessed at each multi-rooted tooth and divided into the following four grades: Grade 0 = furcation is not palpable Grade 1 = furcation is palpable and probable < 3 mm Grade 2 = furcation is probable > 3 but < 6 mm Grade 3 = furcation is probable > 6 mm, for molars in the lower jaw furcation is continuously probable
Degree of tooth mobility	Grade 0 = physiological tooth mobility Grade 1 = horizontal tooth mobility < 1 mm Grade 2 = horizontal tooth mobility > 1 mm Grade 3 = tooth mobility caused by pressure of tongue or lip, vertical tooth mobility
BOP	The presence or absence of bleeding was recorded after gentle probing of the periodontal sulcus. The BOP was calculated by dividing the total number of positive scores by the total number of probed surfaces and was expressed in percent
HI	After staining dental plaque, the presence or absence of dental plaque was recorded at four sites of each tooth. The HI was calculated by dividing the total number of negative scores by the total number of assessed surfaces and was expressed in percent

Abbreviations: BOP, bleeding on probing; CAL, clinical attachment level; GR, gingival recession; HI, hygiene index; PPD, probing pocket depth; PSI, periodontal screening index.

between groups for numerical variables. The analysis of the patients' questionnaires were performed with the χ^2 test. In addition, multivariate regression analysis was applied to identify and rank possible risk factors for periodontal damage. For all tests a P -value of $P \leq 0.05$ was considered to be statistically significant.

RESULTS

A total of 200 patients, 100 vegetarians (71 female and 29 male) aged between 21 and 81 years (mean 41.5 ± 14.1 years) and 100 non-vegetarians (71 female and 29 male) aged between 20 and 80 years (mean 41.7 ± 15.3 years) were examined. The prevalence of smoking individuals was similar in both groups ($n=10$). Regarding the type of vegetarian diet, the vegetarian group consisted of 89 lacto-ovo-vegetarians and 11 vegans.

Periodontal examination

Mean and range values of all periodontal parameters (PPD, GR, CAL, BOP, PSI, degree of furcation involvement, degree of tooth mobility, HI and gingival phenotype) are presented in Table 2.

Vegetarians had significantly lower PPDs (2.01 ± 0.49 mm versus 2.25 ± 0.8 mm; $P=0.039$) and significantly lower BOP ($12.18 \pm 13.12\%$ versus $19.43 \pm 17.4\%$; $P=0.001$) than non-vegetarians. Regarding GR, CAL and degree of furcation involvement, mean values were not significantly different between the groups.

PSI were significantly lower in the vegetarian group (1.87 ± 1.05 versus 2.25 ± 1.05 ; $P=0.012$). The degree of tooth mobility, evaluated as highest degree of tooth mobility and number of mobile teeth, was significantly lower in the vegetarian group ($P=0.037$ and $P=0.013$, respectively).

Regarding the plaque accumulation, the HI was significantly higher in the vegetarian group ($50.62 \pm 18.16\%$) than in the non-vegetarian group ($35.7 \pm 16.98\%$; $P<0.001$).

The distribution of thick and thin gingival biotype was almost similar in both groups.

Dental examination

Mean and range values of DMF-T, DT, MT, FT, DMF-S and number of teeth with erosion are given in Table 3. DMF-T and DMF-S were not significantly different between vegetarians and non-vegetarians. Vegetarians showed significantly less MT (1.53 ± 3.3 versus 2.28 ± 3.67 ; $P=0.018$) but also significantly more DT (1.07 ± 1.89 versus 0.51 ± 1.91 ; $P=0.001$) than non-vegetarians.

Regarding the number of teeth with erosion, vegetarians had significantly more affected teeth ($P=0.026$) than non-vegetarians.

Questionnaire

Analysis of the questionnaire showed that vegetarians had a significantly higher frequency of oral hygiene procedures; however, dentist visits were significantly less frequent. On average, vegetarians had a higher level of education (Table 4).

The mean duration of vegetarian diet in the vegetarian group was 15.1 ± 9.1 years.

Multivariate regression analysis

PPD was selected as the independent variable. Following dependent variables were selected: gender, age, vegetarian or non-vegetarian, HI, DMF-T, smoking habits, frequency of oral hygiene procedures, frequency of dentist visit and level of education.

Multivariate regression analysis showed that PPD was significantly correlated with age and HI only. The variable 'vegetarian or non-vegetarian diet' just failed the level of significance ($P=0.06$).

DISCUSSION

The effects of a vegetarian diet on systemic diseases like cancer, type 2 diabetes and coronary heart diseases have been studied by various authors and revealed predominantly less systemic diseases in vegetarians.^{25,33} Studies investigating correlations between vegetarianism and oral health are rare. Most authors assessed dental parameters or performed a saliva test.³⁴⁻³⁸ Only a few studies investigating the influence of a vegetarian diet on periodontal conditions are available.^{19,39-41} In those publications, the assessment of periodontal conditions was restricted to plaque

Table 3. Mean and range values of all assessed dental parameters and comparison of mean values (Mann-Whitney test)

Clinical parameter	Non-vegetarians (n = 100)	Vegetarians (n = 100)	P-value
DMF-T	13.51 ± 7.60	13.22 ± 6.98	> 0.05
DMF-S	46.67 ± 34.86	43.64 ± 32.97	> 0.05
DT	0.51 ± 1.91	1.07 ± 1.89	= 0.001
MT	2.28 ± 3.67	1.53 ± 3.30	= 0.018
FT	9.82 ± 6.24	8.65 ± 5.91	> 0.05
Number of teeth with erosion	0.40 ± 1.50	0.98 ± 2.70	= 0.026

Abbreviations: DMF-T, index for decayed, missing and filled teeth; DMF-S, index for decayed, missing and filled surfaces; DT, decayed teeth; FT, filled teeth; MT, missing teeth.

Table 2. Mean and range values of all assessed clinical periodontal parameters and comparison of mean values (Mann-Whitney test)

Clinical parameter	Non-vegetarians (n = 100)	Vegetarians (n = 100)	P-value
PPD (in mm)	2.25 ± 0.80	2.01 ± 0.49	= 0.039
GR (in mm)	0.25 ± 0.27	0.22 ± 0.28	> 0.05
CAL (in mm)	2.50 ± 0.96	2.23 ± 0.64	> 0.05
PSI	2.25 ± 1.05	1.87 ± 1.05	= 0.012
Highest degree of furcation involvement	0.36 ± 0.67	0.60 ± 0.80	> 0.05
Number of teeth with furcation involvement	1.35 ± 3.09	2.48 ± 4.36	> 0.05
Highest degree of tooth mobility	0.64 ± 0.81	0.45 ± 0.81	= 0.037
Number of mobile teeth	2.97 ± 5.03	1.50 ± 3.72	= 0.013
BOP (in %)	19.43 ± 17.40	12.18 ± 13.12	= 0.001
HI (in %)	35.70 ± 16.98	50.62 ± 18.16	< 0.0001
Thick gingival biotype (in %)	35.0	44.0	> 0.05
Thin gingival biotype (in %)	65.0	56.0	

Abbreviations: BOP, bleeding on probing; CAL, clinical attachment level; HI, hygiene index; GR, gingival recession; PPD, probing pocket depth; PSI, periodontal screening index.

Table 4. Analysis of the questionnaire

Question	Selected answers	Non-vegetarians (n = 100)	Vegetarians (n = 100)
Frequency of oral hygiene procedures ^a	Per day	2.02 ± 0.49	2.17 ± 0.51
Level of education (in %) ^b	Secondary education	55.0	20.0
	Qualification for university education	24.0	67.0
Frequency of dentist visit per year (in %) ^b	Once	23.0	48.5
	Twice	55.0	34.3
	More than twice	7.0	3.0

^aSignificantly different (Mann–Whitney test). ^bSignificantly different (χ^2 test).

scores, bleeding scores or PSI. In addition, the sample sizes investigated in the above mentioned studies were limited (9 to 29 vegetarians). Accordingly, the present study investigated for the first time the correlation between a vegetarian diet and periodontal conditions with a comprehensive periodontal examination and an appropriate sample size ($n = 200$).

First, our data indicate less inflammation signs in vegetarians. In the scientific literature the effect of a vegetarian diet on periodontal inflammation signs are inconsistent. Linkosalo *et al.*³⁹ investigated 28 vegetarians and could not demonstrate less inflammation signs. In contrast, Linkosalo *et al.*⁴² and Linkosalo¹⁹ revealed a lower BOP in vegetarians compared with the controls. Instead of BOP, Linkosalo *et al.*³⁹ used a less reproducible index called Gingiva Index, which assesses gingival conditions by inspection only. There are several pathways, which may lead to less inflammation signs. Generally, vegetarians show more physical activity and a lower BMI. Hence, the prevalence of obesity, which may cause an increased local inflammatory response is lower.⁴³ Additionally, vegetarians consume a higher amount of antioxidants, which improves immune response,¹⁸ and may lead to less inflammation. Considering plaque scores, our data and most of the available scientific literature^{19,39} revealed a higher HI, as a result of a better dental home care in vegetarians. As of the fact that bacterial biofilm is the primary risk factor for periodontitis,¹² it is obvious that lower plaque scores lead to less inflammation signs.

Second, our data indicate less periodontal damage. No data are available regarding mean periodontal damage after full-mouth periodontal examination in vegetarians like in the present study. In the literature periodontal damage was assessed by the PSI. Thus, Rahmatulla and Guille³⁵ also demonstrated a lower PSI in young vegetarians, whereas Sedgley *et al.*⁴⁰ did not find a difference in PSI between vegetarians and non-vegetarians. As of the mean age of vegetarians investigated by Rahmatulla and Guille³⁵ (12 years) a comparison with the present study is not possible. Possible causes for less periodontal damage in vegetarians are given above (lower BMI, higher consumption of antioxidants, lower plaque scores). The importance of an adequate nutrition for a healthy periodontium was documented by Jenzsch *et al.*⁴⁴ They demonstrated that solely a dietary change according to the recommendations of Körber *et al.*⁴⁵ leads to better periodontal conditions. Jenzsch *et al.*⁴⁴ showed that 1 year after a dietary change without affected dental hygiene and without dental therapy, patients had lower PPDs, less inflammation signs and lower concentrations of interleukin-1 β and interleukin-6 in the gingival crevicular fluid.

Third, the dental examinations revealed more eroded and DT in vegetarians. Regarding the prevalence of erosion, scientific data are inconsistent. Linkosalo and Markkanen³⁴ demonstrated, accordingly to the results of the present study, more erosion in vegetarians. In contrast, other authors could not find a different prevalence of erosion between vegetarians and non-vegetarians.^{19,46} Herman *et al.*⁴⁷ evaluated the prevalence of

erosion and the consumption of acidic products in 46 vegetarians and 46 non-vegetarians. Regarding the prevalence of erosion, they could not show significant differences between the groups (39.1% of vegetarians and 23.9% of controls showed erosion), although a significantly more frequent consumption of acidic products (predominantly raw vegetables, fruits and tomatoes) was observed among vegetarians. A continuous supply of acidic products causes a more acidic environment in the oral cavity. In consequence, demineralization of the teeth predominate remineralization processes. This could be a reason for more DT documented in the present study.

The analysis of the questionnaire revealed a higher level of education and a lower frequency of dentist visit in vegetarians. Several studies have reported a lower use of prescription medications and health services by vegetarians.⁴⁸ In addition, various authors ratified a higher level of education in vegetarians.^{22,48}

While interpreting the present data, one should keep in mind that vegetarianism is not only a form of nutrition but also represents a healthier life style. Vegetarians consume less tobacco and alcohol, are physically more active and have a lower BMI compared with non-vegetarians.^{21,22} In the present study, the vegetarian and non-vegetarian group were matched regarding smoking habits, as smoking is one of the most important periodontal risk factors. However, physical activity and BMI were not evaluated in the present study. Both have an influence on periodontal tissues⁴⁹ and could be considered as a confounder if the correlation between vegetarian diet and periodontal conditions is investigated.

CONCLUSION

A vegetarian diet or vegetarian lifestyle, respectively, has a positive effect on periodontal conditions. Vegetarians show less inflammation signs, less periodontal damage, less MT and as a result of a better dental home care reveal better plaque scores. In addition, vegetarians have a higher level of education. However, regarding the dental conditions, vegetarians show more DT and more erosion.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

DISCLAIMER

We declare that there were no sources of any support for the work, received in form of grants and/or equipment and drugs.

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