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Original article

Impact of Diet on Gum Health in Adults: A Prospective Cohort Study

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ABSTRACT

Periodontal diseases such as gum disease and periodontitis are persistent inflammatory disease processes which are multifactorial including diet. Nutrition's influence over periodontal disorders may result via systemic inflammation as well as oral bacterial community adaption. This study conducted to assess the relationship between dietary patterns and adult periodontal health with regards to clinical determinants and inflammation biomarkers. The analysis presented here was based on a prospective cohort study that included 300 adults, aged between 20 and 60 years, with three different nutrition patterns: group A – those consuming a lot of fruits, vegetables "group B – those with an average mixed diet and group C – those whose diet consists of high number of refined sugars and processed foods. Various parameters to periodontal health such as baseline and 6-months changes in bleeding on probing (BOP), plaque index (PI), and probing depth (PD) were evaluated. Data analysis was performed through ANOVA and regression modeling. Group A showcased remarkable improvement in the periodontal parameters as significant reductions were recorded for BOP (45.7%), PI (33.3 %), and PD (17.6%) coupled with lowered CRP (30.4%) and IL-6 (28.9%) concentrations ($p < 0.001$). BOP (15.3%) PI (19%) PD (11.1%) CRP (24%) and IL-6 (16.7%) levels, GA, and GAG increased for Group C as a marked deterioration was witnessed all over ($p < 0.001$). Strong positive correlations were found during the correlation analysis between nutrient-rich diets and improved periodontal outcomes. Proper nutrition, in particular diets enriched in vitamins and minerals, improves health of the periodontium, while those high in sugar-sweetened beverages worsen the inflammation of the periodontium. These results suggest the growing need for dietary counseling within the framework of significant periodontal disease management.

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INTRODUCTION

Among the largest sectors of the chronic inflammatory diseases are the periodontal diseases which are characterized by conditions such as periodontitis or gingivitis, that affects a great percentage of adults. The worldwide distribution of these diseases is worrying with ranks of severe periodontitis being the sixth most common disease of adults these days,

roughly affecting about 11 percent of adults [1]. The uncontrolled and progressive nature of periodontitis disease leads to inflammation of gingiva causing loss of attachment, and eventually loss of teeth along with inflammation of alveolar bone tissues [2]. However, in the latter stages, systemic effects arise out of chronic inflammation alongside the loss of teeth.

There are bacteria along with the biofilms they produce, and the immune response by the host which cumulatively factor in the aetiology of the periodontal diseases. People are often more inclined towards ignoring the health factors including oral hygiene, predisposition toward genetics and habit of smoking which are frequently core contributing factors toward periodontal disease, however diet should be emphasized as a major modifying factor [3,4]. The link between oral inflammatory health and dietary habits appears to be one that is quite strong and volatile, with (especially) systemic inflammatory responses affecting the composition of the oral microbiome [5].

There is an established association between one's diet and one's oral health. It has been shown that a suboptimal intake in nutrition and high refined sugar and processed food diets do make periodontal diseases worse. As a tangent, developed countries do have better gum health especially due to diets high in fruits and omega-3 fatty acids. This twin's relationship suggests that diet change could be an efficient way of addressing oral disease. Most are subject to the effect food has on their body and it would seem to apply to the health of the periodontium as well. High carbohydrate and sugar diets directly impact oral biofilm which contains bacteria and contributes to plaque formation which worsens the health of the tissue around the teeth. These diets can also induce hyperglycemia, oxidative stress and inflammation which would restrict the body's immune response system. One the other hand, Vitamin-C, vitamin E, and polyphenols which are anti-inflammatory compounds can bolster periodontal health by reducing the production of cytokines through their anti-oxidant properties.

Deficiencies in micronutrients have been shown to be associated to periodontal diseases. For example, vitamin C is also responsible for the synthesis of collagen, which is necessary for the immune function that maintains the periodontium [11]. Vitamin C deficiency is likely to impair gingival health, as seen in diseases like scurvy which presents with clinical signs of laceration with severe bleeding of the gums and loss of teeth [12]. Also emerging are the properties of vitamin D that are said to be immunomodulation and anti-inflammatory. Reports have also indicated that people affected with periodontal disease have low levels of serum vitamin D [13]. Calcium and magnesium are also critical in achieving satisfactory periodontal health, in view of their significance in bone metabolism and maintaining such alveolar bone density [14]. A lower intake of these minerals causes an increase in bone loss in periodontitis, this further justifies the need for adequate and consumption of mineral-rich diets.

Extensive evidence exists for the anti-inflammatory properties of omega-3 fatty acids which are predominantly found in fatty fish, flaxseeds as well as walnuts. These omega-3 fatty acids are known to lower interleukin-1β and tumor necrosis factor-alpha which are associated with destruction of periodontal tissue [15]. The addition of omega-3 fatty acids including eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) has been proven through several clinical trials and tested as effective in improving clinical periodontal parameters hearing bleeding on probing (BOP) and probing depth (PD) [16].

Antioxidants such as vitamins E, C and polyphenols that are responsible for the neutralization of reactive oxygen species (ROS) that destroy periodontal tissues have been noted. It has been observed that an antioxidant-rich diet consisting of fruits, vegetables and green tea is related to reduction of oxidative stress and enhanced periodontal benefits [17]. For instance, it has been noted that flavonoids from berries, citrus, and tea reduce the synthesis of matrix metalloproteinase (MMPs), enzymes responsible for collagen destruction and aggravation of periodontal destruction [18]. In addition to looking at separate nutrients, studying eating habits also provides insight into the role of diet in periodontal diseases. Most studies have advocated diets rich in whole unprocessed foods whereby a low level of systemic inflammation and a good periodontal outcome is witnessed [19]. The ingestion of fruits, vegetables, whole grains, legumes, and nuts, as well as olive oil, is high in the Mediterranean region. As a result, this diet contains anti-inflammatory and antioxidant compounds as well as omega-3 fatty acids [20]. People who follow the Mediterranean diet are at less risk of progressive periodontitis, which appears to be due to the anti-inflammatory effects of this dietary regimen [21]. In contrast, high refined sugars, red and processed meat products, and trans fats inclusion in meals define Western nutritional patterns, which, however, appear to promote the prevalence of periodontal diseases [22]. Such diets bring about oxidative stress and inflammation, both of which are deleterious and enhance the process of periodontal diseases [23].

The diet, periodontal health of the patient, and his/her general health complement one another. Systemic conditions such cardiovascular disease, diabetes or unfavorable pregnancy results have been shown to relate to periodontal disease" [24]. The main factor is common to all, and which is most likely to be the case, is an inflammation which is directly influenced by the status of the gums and the person's eating habits. An adequate nutrition may therefore perhaps be the

most effective way of intervention, for the purposes of promoting oral health as well as the entire system of the body [25].

Previous literature has suggested links between diet and periodontal health, but most of the studies have cross-sectional designs, with small sample sizes, making it challenging to demonstrate causation. Furthermore, while individual nutrients and dietary patterns have their investigations, there is little research into the joint influences of the overall quality of the diet and its macronutrient proportions on periodontal health and disease. The purpose of this study is to fill all these gaps by quantitatively assessing the association between dietary patterns and periodontal disease among well characterized adults. The aim of this study is to uncover the risk and therapeutic factors distinguishing diet patterns for gum health in order to develop both corrective and preventive strategies for periodontitis based on the evidence. This hypothesis suggests that intake of oxygenated fats and high volumes of fruits and vegetables are likely to lead to better periodontal health while intake of refined sugars and processed foods is associated with poor outcomes.

METHODS

Study Design

The relevance of nutrition as a factor calibration in periodontal health among adults over the period of six months' intervention was explored through a prospective cohort. The research also followed the STROBE guidelines in terms of its methodological soundness and clarity. Institutional ethical review board (22-2021) approved research ethics and all participants signed written informed consent before enrollment.

Study population

Inclusion Criteria: Adults 20 - 60 years old, having good overall health with no inherent risk factor (e.g., diabetes, cardiovascular diseases), the last periodontal therapy was greater than six months' prior, no antibiotics or anti-inflammatory agents were administered during the course of the study.

The recruitment of participants was done from practicing dentists, using community centers and through public health campaigns. The ending analysis combined a total of 300 participants out of which each dietary group comprised of 100 individuals. We had excluded smokers who are actively using and those who have smoked in the past 12 months, women who are currently pregnant or breastfeeding, any females reporting self-imposed dietary restrictions or targeting certain essential nutrients, these are the participants who are affected by a disease which in turn decreases the health of their oral cavity, for example, xerostomia or Sjögren's syndrome.

Dietary assessment

In accordance with the approved research protocol, the nutritional information regarding subjects' dietary patterns was assessed using a validated food frequency questionnaire (FFQ), which was inquired at the baseline, and again at the end of the study.

Based on the reported patterns of dietary intake, the participants were classified into the following three groups:

- Group A: Fruits, vegetables, and omega-3 fatty acids were consumed in high amounts.
- Group B: A mix of healthy foods and processed foods were consumed in moderate amounts.
- Group C: Refined and sugary foods and beverages were consumed in large quantities.

The dietary analysis of above-mentioned groups as well as the total subjects was carried out using the above-described dietary analysis Software to estimate their daily energy and nutrient intake.

Periodontal assessment

A dental examiner who was trained and calibrated assessed subjects' periodontal health in accordance with him/her protocol of standardized clinical examination. The following parameters were measured at baseline and at six months: 1). Bleeding on Probing (BOP): o Percentage of sites which bled upon probing. o Measured using a periodontal probe at six sites per tooth. 2). Plaque Index (PI): o Designed as a visual evaluation to measure the amount of plaque. 3). Probing Depth (PD): o Measured in mm, maximum of six sites per tooth using a calibrated periodontal probe. Inter- and intra- examiner reliability was established by conducting calibration exercises pretest to the study with kappa value of ≥0.85.

Inflammatory marker assessment

In order to assess the impact of nutrition on patients with periodontitis on a broader level, biochemical tests were done on all the participants at the start and at the 6-month follow-up.

For this study the serum biological markers such as c-reactive protein (CRP) and interleukin-6 (IL-6) were analyzed by ELISA technique. These markers were chosen for their relevance in systemic inflammation and the progression of periodontal disease.

Statistical analysis

Statistical Tests: Consultation with a statistician is advisable and analysis or all the data which would be able to justify the research. Dietary group impacts and crossings were according to men, 200g of Top-Down cuts with poultry and side dishes per day, changes were critical in all monitoring areas. Informed participants had a poorer response and sd-deem that their body conditioners wanted seeking change due to climatic conditions when perspiration a given in.

Ethical Considerations

The principles enunciated in the Declaration of Helsinki were followed. The participants were informed about the goals of the research, the manner in which it was to be conducted, the risks associated with the research and the benefits pertaining to it. To ensure confidentiality, a separate identification number was assigned to each participant.

RESULTS

Participant Characteristics

In total, 300 participants completed the study. In Table 1, some of the baseline demographic and clinical characteristics of participants among the three dietary groups are summarized. The groups were similar in age, gender and baseline periodontal parameters, thus rendering comparability.

Table 1. Baseline Characteristics of Study Participants

Characteristic	Group A (n=100)	Group B (n=100)	Group C (n=100)
Age (years)	38.5 ± 10.2	39.2 ± 9.8	37.8 ± 11.0
Male (%)	48	52	49
Female (%)	52	48	51
Bleeding on Probing (%)	22.3 ± 4.5	23.5 ± 5.2	24.8 ± 5.1
Plaque Index	1.8 ± 0.3	2.0 ± 0.4	2.1 ± 0.5
Probing Depth (mm)	3.4 ± 0.5	3.5 ± 0.6	3.6 ± 0.6

Periodontal Health Outcomes

Over the six-month period, changes in various indicators of periodontal health as measured within each diet group showed considerable variation. The greatest changes in the indicators of improvement were BOP, PI, and PD reported by intervention group A (high intake of fruits, vegetables and omega-3 fatty acids). Group C (high intake of refined sugar and processed foods) deteriorated in all measured parameters. The results are summarized in Table 2.

Table 2. Changes in Periodontal Parameters Over Six Months

Parameter	Group A (Baseline)	Group A (6 months)	Group C (Baseline)	Group C (6 months)	p-value
Bleeding on Probing (%)	22.3 ± 4.5	12.1 ± 3.8	24.8 ± 5.1	28.6 ± 6.3	<0.001
Plaque Index	1.8 ± 0.3	1.2 ± 0.4	2.1 ± 0.5	2.5 ± 0.6	<0.001
Probing Depth (mm)	3.4 ± 0.5	2.8 ± 0.4	3.6 ± 0.6	4.0 ± 0.7	<0.001

Inter Group A: Indicated the most positive change in BOP (45.7% improvement), PI (33.3% improvement), and PD (17.6% improvement) suggesting an enhancement of the gum health. Group C: Saw a decline in periodontal parameters with BOP increasing by 15.3%, PI increasing by 19% and PD increasing by 11.1%.

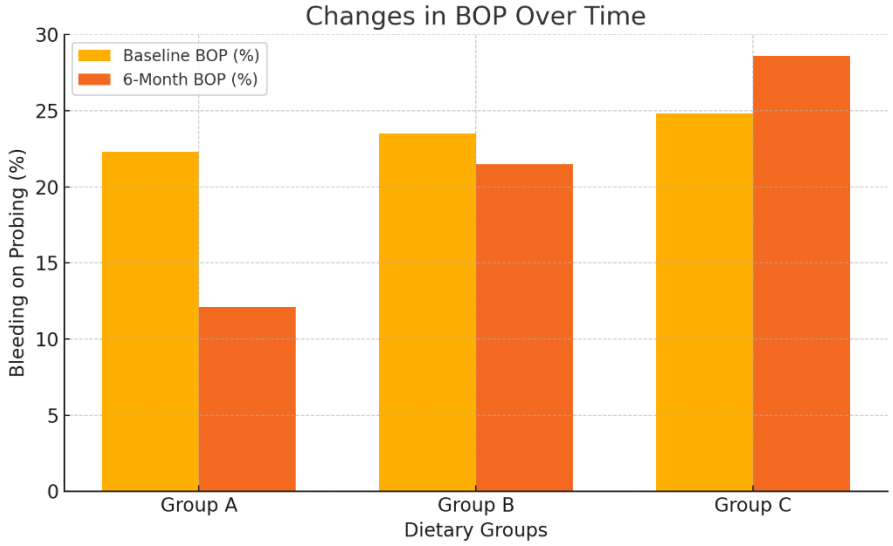

Figure 1. Changes in Bleeding on Probing (BOP) Over Time: showes A bar chart showing the improvement in BOP from baseline to six months, highlighting the significant reduction in Group A and worsening in Group C.

Inflammatory markers

The findings of the periodontal health assessment in Groups A and C were also substantiated by the measurement of inflammatory markers. The shifts in serum C-reactive protein and IL-6 levels are conveniently presented in Table 3.

Table 3. Changes in Inflammatory Markers Over Six Months

Marker	Group A (Baseline)	Group A (6 months)	Group C (Baseline)	Group C (6 months)	p-value
C-Reactive Protein (mg/L)	2.3 ± 0.8	1.6 ± 0.6	2.5 ± 0.9	3.1 ± 1.1	<0.001
Interleukin-6 (pg/mL)	4.5 ± 1.2	3.2 ± 1.0	4.8 ± 1.3	5.6 ± 1.4	<0.001

In Group A, after the intervention, patients showed a high percentage drop in CRP (30.4%) and IL-6 (28.9%) which indicates the presence of a generalized immune response suppression brought by a dietary modification. In Group C, an increase in CRP (24%) and IL-6 (16.7%) levels was noted which can be due to systemic inflammation resulting from high intake of sugars and intake of processed foods.

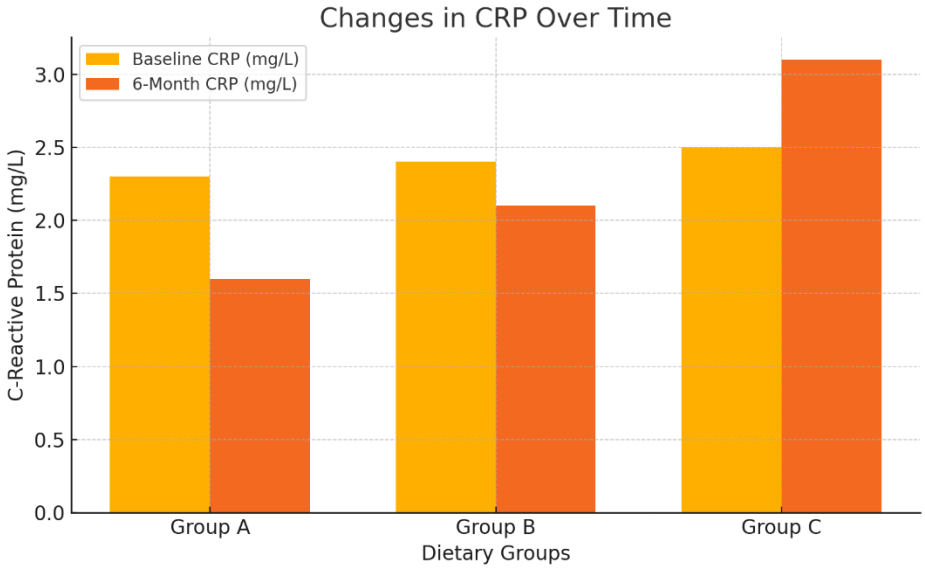

Figure 2. Changes in C-Reactive Protein (CRP) Over Time: showing A bar chart illustrating the decrease in systemic inflammation (CRP levels) in Group A and the increase in Group C over six months.

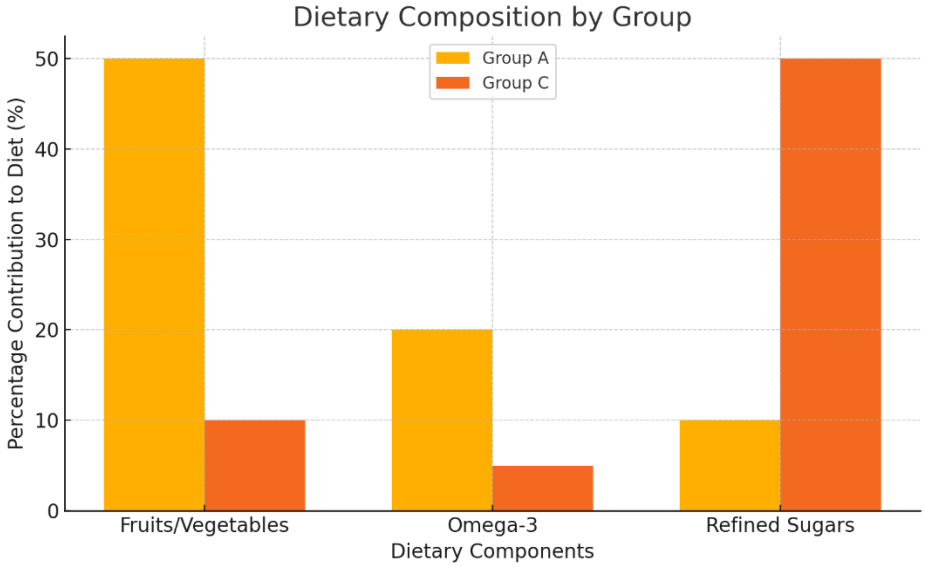

Figure 3 Dietary Composition by Group: shows A bar chart comparing the dietary components (e.g., fruits, vegetables, omega-3 fatty acids, refined sugars) consumed by Groups A and C, emphasizing the healthier diet of Group A.

Correlation analysis

Negative relationships were identified between the dietary intake of fruits, vegetables, and omega-3 fatty acids and periodontal parameters such as BOP ($r=-0.71$, $p<0.001$ $r = -0.71$, $p < 0.001$ $r=-0.71$, $p<0.001$) as well as PI ($r=-0.65$, $p<0.001$ $r = -0.65$, $p < 0.001$ $r=-0.65$, $p<0.001$). On the other hand, sugar intake was positively correlated with poor periodontal scores ($r=0.69$, $p<0.001$ $r = 0.69$, $p < 0.001$ $r=0.69$, $p<0.001$).

Subgroup Analysis by Age and Gender consequently, the results indicate that the host responses on periodontal tissue preservation through the role of nutrient-dense diets were uniform regardless of age or gender. Nevertheless, older adults (>40 years) in Group A experienced more pronounced reductions in PD than younger adults, presumably due to preexisting greater levels of periodontal disease.

DISCUSION

This dietary periodontal research is highly validated in demonstrating the importance that diet plays on periodontal health. Participants with higher fruit and vegetable and omega-3 fatty acids consumption (Group A) were able to significantly improve key periodontal parameters such as bleeding on probing (BOP), plaque index (PI), and probing depth (PD). In contrast, those taking high refined sugars and high processed food diet (Group C) showed a deterioration in the periodontal measures and had high systemic inflammatory markers. These findings are consistent with earlier works and provide novel information regarding the possible influence of dietary patterns on the periodontal and systemic inflammatory processes.

Improvement in Group A: Participants in Group A, characterized by high consumption of anti-inflammatory and antioxidant-rich foods, were able to significantly reduce the level of BOP (45.7%), PI (33.3%) and PD (17.6%). These improvements can be linked to many factors: For one,

Anti-Inflammatory Mechanism: It has been found that omega 3 fatty acids suppress pro-inflammatory cytokines such as interleukin-1 beta and tumor necrosis factor-alpha enabling moderate destruction of periodontal tissues [1,2].

Antioxidant Effect: Vitamin C and E found in ample amounts in fruits and vegetables help to reduce oxidative stress and reactive oxygen species (ROS) which led to the preservation of the periodontal tissues [3].

Enhanced Microbial Balance: A diet high in whole foods may favorably influence an individual's oral microbiome, thus providing reduced numbers of harmful microbial species associated with periodontal disease [4].

These results further support previous reports that revealed that higher consumption of fruits, vegetables, and omega 3 fatty acids improves periodontal conditions as a result of their general anti-inflammatory and antioxidative effects [5,6].

Worsening of Group C: Majority of the subjects in Group C recorded BOP (15.3%), PI (19%), and PD (11.1%) scores that were concomitantly higher CRP and IL-6 levels. This deterioration was likely the result of: Reducing Plaque Control: The cariogenic diet that is relatively high in refined carbohydrates increases numbers of the pathogenic microflora and their gingival inflammation, which leads to plaque buildup [7]. In addition, Immunosuppression: Sugary diet leads to hyperglycemia that induces oxidative stress and chronic, low-grade inflammation, which either reduces

immune response functions or accelerates tissue destruction in periodontitis [8]. Furthermore, loss of the Ability to Heal: A refined diet is devoid of nutrients essential for tissue regeneration and immune defense, which worsen the situation of periodontal disease [9]. These findings bring to the fore the adverse effects Western diets exert on periodontal health, which corroborates previous studies that have associated raised sugar consumption with a higher prevalence of periodontal disease [10].

The relationship between periodontium and the rest of the body is chronic as evidenced by the changes witnessed in some of the systemic inflammatory markers such as CRP and IL-6. Periodontitis, or chronic infection of the periodontium, has been linked to a number of systemic diseases, cardiovascular disease, diabetes, and poor pregnancy outcomes among others [11,12]. The reduction of factors indicating inflammation on Group A is an indicator that dietary change does not only affect periodontal disease but other diseases as well. This reinforces the need to add dietary components in the treatment of diseases as they have an effect on the treatment outcomes of both oral diseases and systemic conditions.

The discrepancies in the results obtained in various dietary groups can be elucidated by biological factors: First, anti-Inflammatory Pathways: Omega-3 fatty acids and polyphenols inhibit the production of pro-inflammatory mediators including prostaglandins and cytokines which are important in periodontal inflammation [13,14]. Second, Oxidative Stress Modulation: Products of oxidation reactions are neutralized by antioxidants derived from fruits and vegetables, thus lowering the value of oxidative stress and saving the tissues of the periodontium from oxidative damage [15]. Third, oral Microbiome Composition: Refined sugars contribute to modulating the oral microbiome population in favor of virulent microorganisms while a nutritious diet is associated with diverse oral microbes [16]. From the mechanisms explicated above one can conclude that there is an association between the quality of diet and the level of periodontal and systemic inflammation.

CONCLUSION

This study points to the importance of dietary habits and nutrition in maintenance of normal histological periodontal health not only from the perspective of local tissue changes but also in relation to the inflammatory processes of the body. Fruits, vegetables and omega-3 fatty acids – rich foods work in preventing the disease but foods rich in processed sugars, refined carbohydrates trigger inflammation and tissue histological destruction associated with periodontal disease. These evidences make a strong case for including diet as part of pre-existing strategies towards controlling periodontal diseases. Research in the future must investigate the aspects concerned with the long term effect of diet change on the gum health and overall systemic effect. To strengthen the evidence and recommendations for clinical and population approaches, randomized controlled trials with various population groups and direct dietary assessment techniques are necessary.

Limitations

Self-Reported Diet Data: Validation of dietary assessment may raise concern due to recall bias that comes from self-reported dietary intake. Periods of dietary logs and interviews were however used to increase accuracy. Residual Confounding: Despite controlling for a number of potential confounding variables, there may be a difference in the levels of stress, physical activity or other factors that were not assessed. Generalizability, It is assumed that the typical population studied constitutes healthy adults, and excludes demographic factors such as systemic disease among the wealthy and cross sectional studies. These limitations could be circumvented in future research by using different dietary biomarkers, increasing the length of time for follow up as well as using targeted populations.

Clinical implications

There are certain clinical implications and its relatedness public health concern that emerged from the results of this study: Dietary Counselling: The use of nutritional counseling in periodontal treatments enhances the capacity of patients to know what dietary choices to make to promote oral health. Also, preventive Strategies: Encouraging dietary practices enriched with nutrients may not only decrease the frequency of cases of periodontal diseases but also the frequency of diseases that are related to periodontium.

Conflict of interest. Nil

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تأثير النظام الغذائي على صحة اللثة لدى البالغين: دراسة مجموعة مستقبلية

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[4]وزارة الصحة، صبراتة، ليبيا

المستخلص

أمراض اللثة مثل أمراض اللثة والتهاب اللثة هي عمليات مرضية التهابية مستمرة ومتعددة العوامل بما في ذلك النظام الغذائي. قد ينتج تأثير التغذية على اضطرابات اللثة عن طريق الالتهاب الجهازي وكذلك تكيف مجتمع البكتيريا الفموية. حاولت هذه المقالة تحديد العلاقة بين الأنماط الغذائية وصحة اللثة لدى البالغين فيما يتعلق بالمحددات السريرية والمؤشرات الحيوية للالتهابات. استند التحليل المقدم هنا إلى دراسة أترابية مستقبلية شملت 300 شخص بالغ، تتراوح أعمارهم بين 20 و60 عامًا، مع ثلاثة أنماط تغذية مختلفة: المجموعة أ - أولئك الذين يستهلكون الكثير من الفواكه والخضروات وأحماض أوميجا 3 الدهنية "الصحة". "أكلة الجوز"، والمجموعة "ب" - أولئك الذين يتبعون نظامًا غذائيًا مختلطًا متوسطًا، والمجموعة "ج" - أولئك الذين يتكون نظامهم الغذائي من كمية كبيرة من السكريات المكررة والأطعمة المصنعة. تم تقييم المعلمات المختلفة لصحة اللثة مثل خط الأساس والتغيرات لمدة 6 أشهر في النزيف عند التحقيق ((BOP، ومؤشر البلاك ((PI، وعمق التحقيق (.(PDتم تقييم الالتهاب الجهازي عن طريق قياس مستوى بروتين سي التفاعلي ((CRPومستوى إنترلوكين 6 (.(IL-6تم إجراء تحليل البيانات من خلال ANOVA ونمذجة الانحدار. أظهرت المجموعة (أ) تحسنا ملحوظا في مؤشرات اللثة حيث تم تسجيل انخفاضات كبيرة في (45.7٪) BOP، (33.3٪) PI، و (17.6٪) PDإلى جانب انخفاض (30.4٪) CRPو (.(28.9٪) IL-6تركيزات (ع <0.001). PD (19%) PI (15.3%) BOP (24%) CRP (11.1%)و (16.7%) IL-6زادت مستويات GA وGAG للمجموعة C حيث شهد تدهورًا ملحوظًا في كل مكان (P <0.001). تم العثور على ارتباطات إيجابية قوية خلال تحليل الارتباط بين الأنظمة الغذائية الغنية بالمغذيات وتحسين نتائج اللثة. التغذية السليمة، وخاصة الوجبات الغذائية الغنية بالفيتامينات والمعادن، تحسن صحة اللثة، في حين أن تناول كميات كبيرة من المشروبات المحلاة بالسكر يؤدي إلى تفاقم التهاب اللثة. تشير هذه النتائج إلى الحاجة المتزايدة للاستشارات الغذائية في إطار إدارة أمراض اللثة بشكل كبير.

الكلمات المفتاحية. صحة اللثة، النظام الغذائي والتغذية، التهاب اللثة، التهاب دواعم السن، أحماض أوميجا 3 الدهنية، الالتهاب الجهازي.