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Evaluation of serum mineral micronutrients (Zn, Cu, Fe, and Mg) and their correlation with clinical parameters (gingival index, probing pocket depth, and clinical attachment loss) in chronic periodontitis patients

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ABSTRACT

Background: Nutrition especially micro-mineral nutrients plays a major role in the etiology of chronic periodontitis. Serum levels of micro-mineral nutrients can be used as markers for the incidence of periodontitis and may also be used as indicators for dietary supplementation. **Aims and Objectives**: The aim of the study was to estimate the serum levels of Zn, Cu, Fe, and Mg of chronic periodontitis patients and normal healthy controls., to measure the clinical parameters (gingival index, probing pocket depth [PPD], and clinical attachment loss) in chronic periodontitis patients and normal healthy controls., to compare the levels of serum Zn, Cu, Fe, and Mg levels of chronic periodontitis patients and healthy controls and to correlate the levels of serum micronutrients with clinical parameters (gingival index, PPD, and clinical attachment loss) in chronic periodontitis patients and healthy controls. **Materials and Methods:** A total of 110 subjects, 55 subjects with chronic periodontitis and 55 healthy control subjects in the age group 35–65 years were selected for the study. Serum micronutrient levels of Cu, Fe, Zn, Mg, and the clinical parameters were measured. **Results:** Serum concentrations of Cu and Fe showed statistically significant increase and serum Zn and Mg showed a significant decrease in peridontitis patients as compared to normal healthy controls. Copper and Fe showed a significant positive correlation and Zn and Mg showed a significant negative correlation with clinical parameters (gingival index, PPD, and clinical attachment loss). **Conclusion:** The present study supports and extends the view that the assessment of serum mineral micronutrient can serve as possible biomarkers or indicators for an inflammatory condition like chronic periodontitis.

Key words: Mineral micronutrients; Iron; Copper; Zinc; Magnesium; Periodontitis

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INTRODUCTION

Periodontitis is a highly prevalent and complex disease initiated by a plaque biofilm and exaggerated by host immune inflammatory response. The driving factors which may contribute to the development and progression of periodontitis include genetic makeup, lifestyle choices, environmental factors, and medication.[1] The onset and progression of disease depend on a delicate equilibrium between the microbial challenge and host response. Mineral micronutrients have been implicated in a wide variety of inflammatory conditions.[2] The deficiency or excess of essential micronutrients may result in severe malfunctioning of the body because these directly influence

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the metabolic and physiological processes in the organism. Poor nutrition and hence lack of micronutrients may lead to reduced immunity, augmented vulnerability to various oral and systemic diseases, and impaired mental and physical growth. The manifestations of under-nutrition as well as over-nutrition of micronutrients on oral health are vast and may lead to defects of the dental hard tissues as well as oral mucosa.[3-5]

The oral cavity, like any other tissue, undergoes inflammation and injury due to the production of reactive oxygen species (ROS) by immune cells stimulated by pathogens.[6] Periodontium can also enter a state of oxidative stress due to the onset of inflammation initiated by microbial infection or trauma.[7] It is evident that deficiency of micronutrients can affect periodontal health. A number of factors are involved in reducing the level of serum micronutrients such as genetic, gastrointestinal disorders, poor diet, and life style.[8] Certain physiological conditions such as pregnancy and ageing can also affect the daily nutrient requirements.[9] Oral health may be compromised due to various factors such as loss of teeth, oral prosthesis, lack of apetite, masticatory ability, altered taste, and other gastrointestinal conditions. Numbers of natural teeth are reduced as age advances which expose remaining teeth to higher masticatory stress. In addition polypharmacy and reduced body metabolism as in ageing can lead to impaired nutritional status. Considering the role of nutrition for oral and periodontal health, nutritional advice may be helpful for the prevention and management of periodontal diseases.

Poor dietary habits or inadequate nutrition can be highly prevalent among patients with periodontal disease. The effects of malnutrition on wound healing are particularly important to be addressed since identification of plaucible factors on the healing response following periodontal therapy may lead to improved patient care and treatment outcomes. Evidences suggest that even subtle alterations in micronutrient levels can have an impact on periodontal health.

Periodontitis is an inflammatory disease of the supportive tissues of the teeth caused by specific microorganisms or groups of specific microorganisms, resulting in progressive destruction of the periodontal ligament and alveolar bone causing increase in probing depth and recession.[1] It has been estimated that 40–90% of the global population is affected by periodontitis, making it one of the most prevalent epidemics in the world.[10,11]

Inflammatory factors are released by immune cells which may lead to the destruction of periodontal tissue. Polymorphonuclear leukocytes are attracted to the site of periodontitis due to the presence of bacteria.[12,13] Periodontal therapy has traditionally been directed at reduction of the bacterial load to a level that encourages health-promoting bacteria and maintenance of oral hygiene.[14,15] The role of nutrition in different chronic inflammatory diseases has been the subject of an increasing body of research in the past years. In this context, there has been an important surge in the amount of research on the role of nutrition in periodontitis since the diet has known effects on the immune system and inflammatory cascades.[5]

Understanding the role and implication of different nutrients should allow identifying nutritional risk factors and modulators of periodontal inflammation for targeted prevention and treatment approaches in patients with specific nutritional depletion.[6,7] The absorption and metabolism of dietary nutrients determined by genetic factors are key to the underlying reasons of inflammatory processes. Nutrition has significant effects on the inflammatory processes as well as on the cellular and humoral immune mechanisms. The generation of factors responsible for the progression of periodontal disease may be due to the interaction between the nutritional status and the immune response.[8,9]

Diet is a major factor in the development and progression of dental caries. Although dietary components play a major role in the pathogenesis of dental caries, diet plays primarily a modifying role in the progression of periodontal disease.[16] A periodontal lesion is essentially a wound, and sufficient host resources must be available for optimal healing to take place.[17] Nutrients derived from the diet are essential for life by providing a vital energy source (macronutrients) and also provide essential cofactors required for enzyme function, structural moieties, and transport (micronutrients).[18-20] Micronutrients are shown to play major roles in both health and disease.[21] The vitality of the periodontal tissues in both health and disease depends on the adequate source of essential nutrients being available to the host.[22,23] Deficiency or unavailability of micro and macronutrients leads to malnutrition and are detrimental to periodontal health as well as to general health.[24] An understanding of the mechanism which leads to the destruction of periodontal tissue and the protective role played by nutrients have attracted the attention of various researchers. The literature reveals that trace mineral insufficiency has far reaching consequences both systemically and orally.[25-27] Even though, numerous studies have evaluated the relationship between the micronutrients and periodontal disease, intervention studies utilizing the trace minerals in humans are scarce.

Researchers have found irrefutable evidence that macronutrients and micronutrients modulate pro-inflammatory and anti-inflammatory cascades, which influence a person's baseline inflammatory status.[28] Recently

dental caries, periodontitis, oral cancer, and precancerous conditions as well as oral mucosal disorders have been considered to be linked to nutritional deficiencies. However, the precise associations of these mechanisms have not yet been established. The functionality of nutrients in human biology extends beyond fuels for energy production and cofactors in metabolism. The key micronutrients and macronutrients modulate inflammation, and also act as molecular signals that can modulate gene and protein expression. Hence, the purpose of this clinical study was intended to evaluate the possible association of micronutrients and periodontal diseases.

Aims and objectives

The aim of the study was to assess the levels of serum micronutrients (Zn, Cu, Fe, and Mg) level in the serum of chronic periodontitis patients and controls and to correlate these levels with clinical parameters (gingival index, PPD, and clinical attachment loss) in chronic periodontitis patients.

The objectives of the study are as follows:

- To estimate the levels of Zn, Cu, Fe, and Mg level in the serum of chronic periodontitis patients and normal controls
- To measure the clinical parameters (gingival index, PPD, and clinical attachment loss) in chronic periodontitis patients and normal controls
- To compare the levels of serum Zn, Cu, Fe, and Mg levels of chronic periodontitis patients and healthy controls
- To correlate the levels of serum micronutrients with clinical parameters (gingival index, PPD, and clinical attachment loss) in chronic periodontitis patients and controls.

MATERIALS AND METHODS

Setting

The present study was conducted after the Institutional Ethical Committee approval on 110 patients drawn from the Departments of Periodontology and Implantology, PSM Dental College, Kerala.

Ethical consideration

Ethical clearance was obtained for the study from the Institutional ethics committee (No.41/Ethics/PSMCDSR/2019 dt. November 29, 2019).

Sample size

Total number of 110 subjects, 55 in case group and 55 in control group.

- SAMPLING:
  - SAMPLE SIZE:

$$n = 2\left\{\frac{(z_1+z_2)\,sd}{d}\right\}^2$$

$$n = 2\left\{\frac{(1.96+1.282)\,18.77}{11.58}\right\}^2 = 55.229 \sim 55 \text{ in each group}$$

Z_1= Constant at 95% confidence interval

Z_2 = Constant at 90% power

S_d = Standard deviation from parent article

d = Clinically significant difference

N=55 (in each group)

Inclusion criteria

- The following criteria were included in the study: Subjects who are willing to take part in the study with informed consent
- Age between 35 years and 65 years
- Minimum 20 teeth
- Subjects with moderate periodontitis according to the 2018 classification of periodontal disease having generalized (i) PPD ≤5 mm (ii) CAL 3–4 mm (iii) Gingival index score less than 2 (iv) No tooth loss.

Exclusion criteria

The following criteria were excluded from the study:

- Patient having any systemic disease
- Those who have received any topical or systemic antimicrobial treatment/periodontal treatment in past 6 months
- Pregnant and lactating mothers
- Smokers and alcoholics
- History of any vitamins/minerals or antioxidant supplements intake during the past 3 months.

Group distribution

Patients from Department of Periodontics of PSM Dental college, Akkikavu, satisfying all exclusion and inclusion criteria described above were selected by convenient sampling and assigned to Group I and Group II. Informed consent was obtained from all the patients participating in the study.

Group I: Patients with Chronic Periodontitis

Patient selection was done based on

1. Probing pocket depth (PPD) ≤5 mm
2. Clinical Attachment Loss (CAL) 3–4 mm
3. Gingival index score >2.

Group II: Healthy controls

1. PPD ≤3 mm
2. No evidence Clinical Attachment Loss
3. Gingival index score <2.

Periodontal clinical parameters

PPD, CAL, and GI were measured as described earlier.[29,30]

Mineral micronutrients (Zn, Cu, Fe and Mg)

After examination and grouping, approximately 5 mL of blood was drawn from antecubital vein of each subject. Samples were centrifuged at 3000 rpm at 15 min and supernatant serum was separated and transferred to vials using a micropipette and was stored at a −4°C. Zinc, Cu, and Fe were estimated by atomic absorption spectrophotometry and Mg was measured colorimetrically using biochemistry analyzer.

Statistical analysis

The collected data were entered into Microsoft excel sheet and analyzed using Statistical Package for the Social Sciences Software (SPSS Version 22, Armonk, NY: IBM Corp). Descriptive statistics were presented as distribution tables with values for mean, standard deviation, and 95% confidence intervals. Independent sample t test was used for comparison between the two study groups. Chi-square test was used to compare the groups based on categorical variables. The correlation among all parameters was analyzed using Pearson Correlation, P≤0.05 was considered as statistically significant.

RESULTS

Age and sex distribution of subjects

A total of 110 subjects participated in the study were allotted into case group and control group with 55 subjects each, based on their eligibility criteria. The age and gender distribution of the study subjects represented in Table 1.

Table 1: Age and gender distribution of the study population

Group	Age (years)	Males (%)	Females (%)
Control (n=55)	41.4±6.1	23 (41.8)	32 (58.2)
Cases (n=55)	44.0±7.6	37 (67.3)	18 (32.7)

Periodontal clinical parameters

Clinical parameters – Gingival index scores (GI), PPD, and CAL values in cases and controls are depicted in Table 2.

Table 2: Periodontal clinical parameters – gingival index, PPD, and CAL in periodontitis patients and control subjects. (Values are represented as mean±SD)

Group	Gingival index score	PPD	CAL
Control (n=55)	1.06±0.18	1.45±0.18	0.72±0.19
Case (n=55)	2.65±0.22	3.86±0.15	3.97±0.45
Level of significance	P<0.001	P<0.001	P<0.001

PPD: Probing pocket depth, CAL: Clinical attachment loss

The values obtained for the case group are compared with those of control group and were found to be statistically significant (P<0.001).

The mean GI score was 0.6618 for the control group and 1.6509 for the case group. Considering PPD and CAL, the mean recordings were 1.4460 mm and 0.7164 mm for the control group while the corresponding values for the periodontitis group were 3.8615 mm and 3.9713 mm, respectively. All the clinical parameters in the case group showed statistically significant increase when compared to the control group.

Serum mineral micronutrients

Serum levels of mineral micronutrients – copper (Cu), iron (Fe), zinc (Zn), and magnesium (Mg) – are summarized and presented in Table 3. The serum levels of micronutrients copper and iron were significantly (P<0.001) higher in the case group compared to the control group. Zinc (P<0.001) and magnesium (P<0.05) showed statistically significant decrease in cases group when compared to the control group.

Correlation between micronutrients and clinical parameters – A statistically significant (P<0.001) strong positive correlation was observed between GI score (0.639), PPD (0.634), CAL (0.650) scores, and serum copper levels (Graphs 1-3).

The correlation coefficients for serum iron were 0.697 (GI), 0.722 (PPD), and 0.749 (CAL) showing significant (P<0.001) positive correlation (Graphs 4-6).

Serum zinc concentration showed significant negative correlation with gingival index (−0.589), periodontal probing depth (−0.652), and clinical attachment loss (−0.671) (Graphs 7-9).

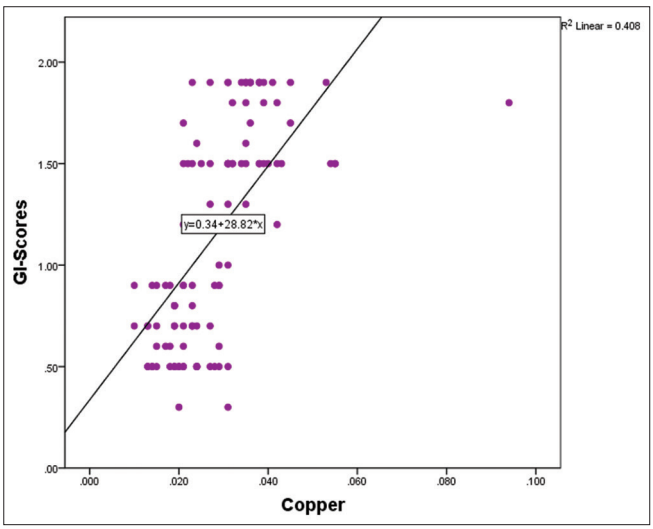
Serum magnesium exhibited negative correlation for gingival index (−0.174), periodontal probing depth (−0.220), and clinical attachment loss (−0.241) which was not statistically significant (Graphs 10-12).

DISCUSSION

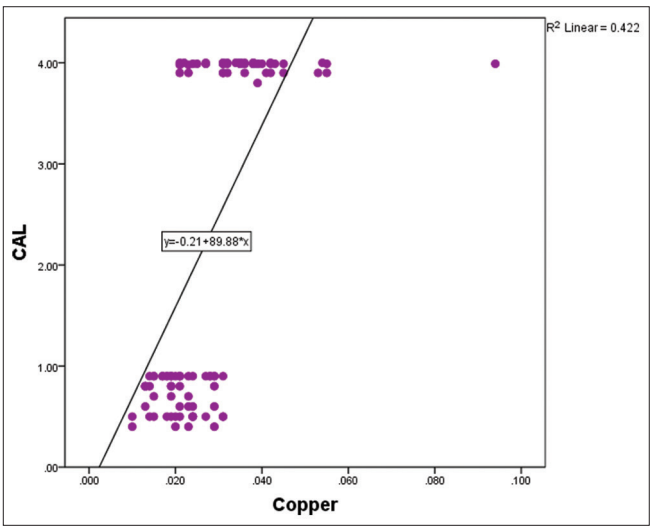
Nutrition is the mainstay of good health and immune system and it has significant effects on the inflammatory processes. Nutritional status and the immune response to infection may play a role in the pathogenesis and progression of periodontal disease. Periodontal pathogens can stimulate the leukocytes to generate destructive oxidants and proteinases. Onset and progression of inflammatory disease depend on a delicate equilibrium between the microbial challenge and the host response. The role of mineral micronutrients in maintaining periodontal health has been exhaustively

Table 3: Serum mineral micronutrients (Cu, Fe, Zn, and Mg) in periodontitis patients and control subjects. (Values are represented as mean±SD)

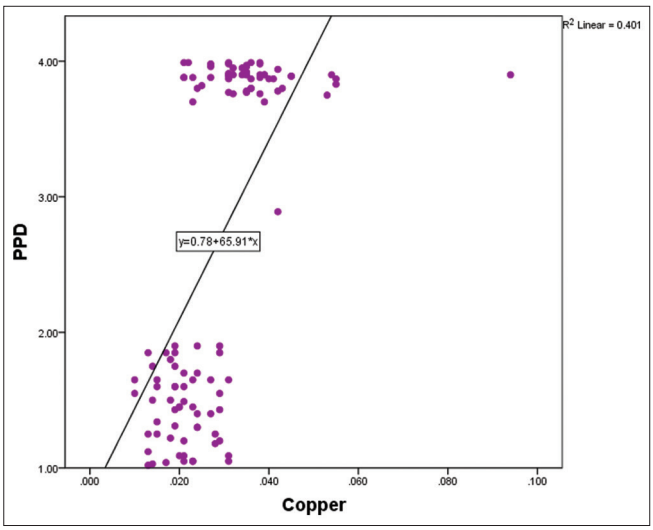
Group	Cu (mg/dl)	Fe (mg/dl)	Zn (mg/dl)	Mg (mg/dl)
Control (n=55)	0.108±0.056	0.166±0.043	0.101±0.018	1.70±0.27
Case (n=55)	0.262±0.021	0.0291±0.065	0.0728±0.013	1.57±0.26
Level of significance	P<0.001	P<0.001	P<0.001	P<0.05



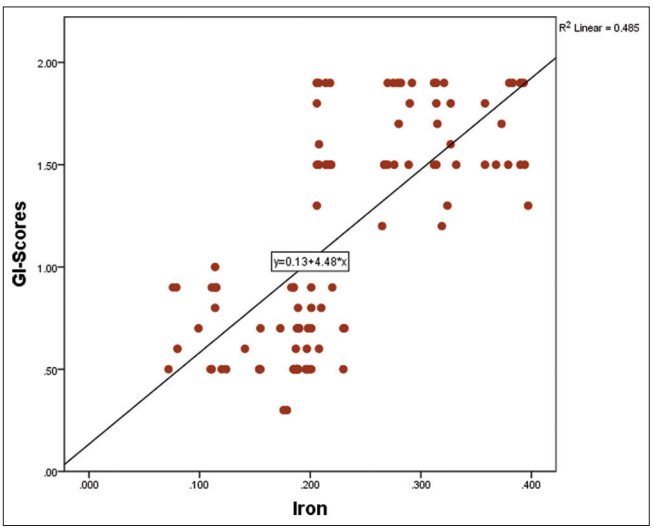
Graph 1: Correlation between serum copper levels (mg/dl and gingival index) scores in periodontitis patients and normal controls
Serum copper levels when correlated with GI scores showed a positive correlation (Correlation coefficient=0.639)



Graph 3: Correlation between serum copper levels (mg/dl) and clinical attachment loss (CAL) in periodontitis patients and normal controls
Serum copper levels on correlation with CAL showed a positive correlation (Correlation coefficient=0.650)



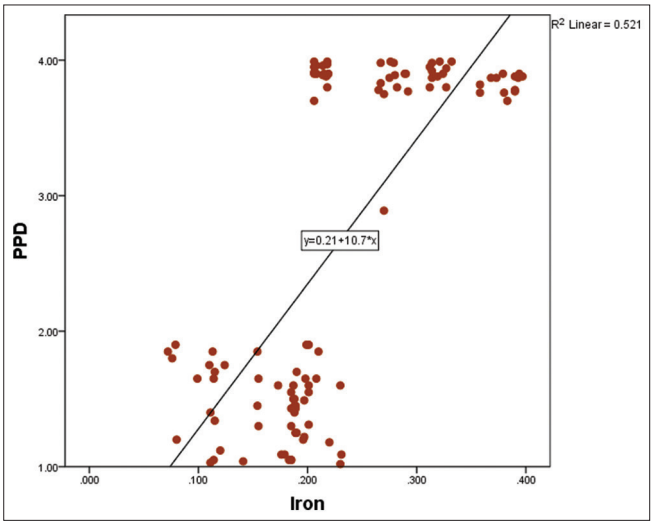
Graph 2: Correlation between serum copper (mg/dl) levels and probing pocket depth (PPD) in periodontitis patients and normal controls
Serum copper levels on correlation with PPD showed a positive correlation (Correlation coefficient=0.634)



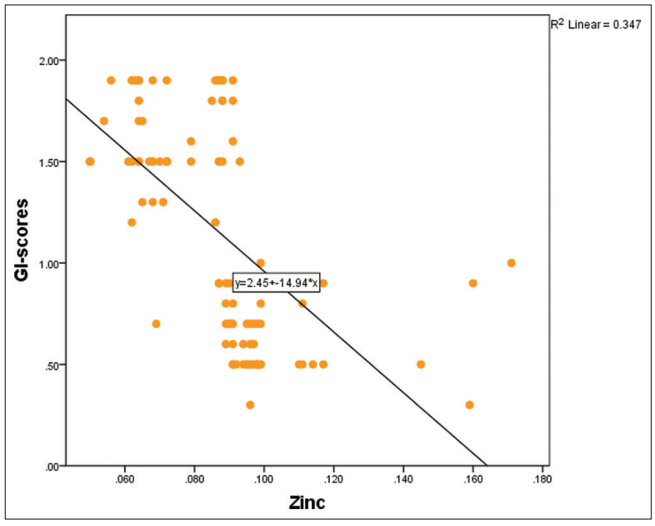
Graph 4: Correlation between serum iron levels (mg/dl) and gingival index (GI) scores in periodontitis patients and normal controls
Serum iron levels on correlation with GI scores showed a positive correlation (Correlation coefficient=0.697)

reviewed by Sumit and Rupali.[2] Periodontal disease can lead to alteration of the mineral micronutrient levels such as zinc, magnesium, iron, and copper. Susceptibility of tissues to oxidative stress may be due to imbalance in micronutrient levels. Balanced levels of these trace minerals such as iron, zinc, magnesium, and copper are essential to prevent progression of chronic conditions like periodontitis. Zinc and copper are integral components of antioxidant enzymes and their deficiency can worsen periodontitis.

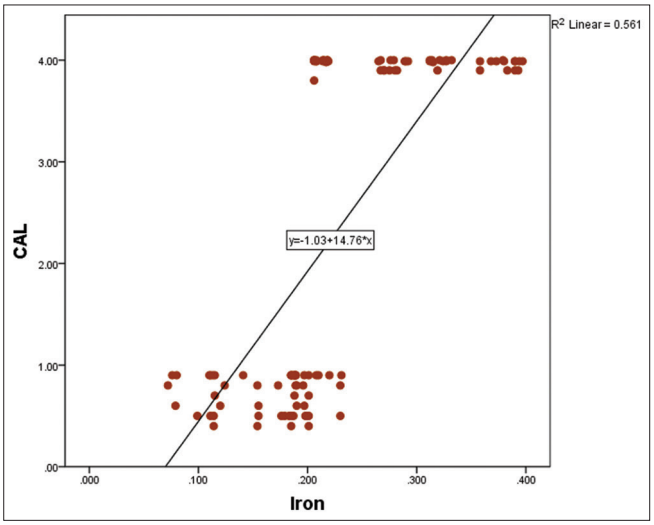
Even though the trace mineral micronutrients, Zn, Fe, Mg, and Cu, have been deeply investigated for their



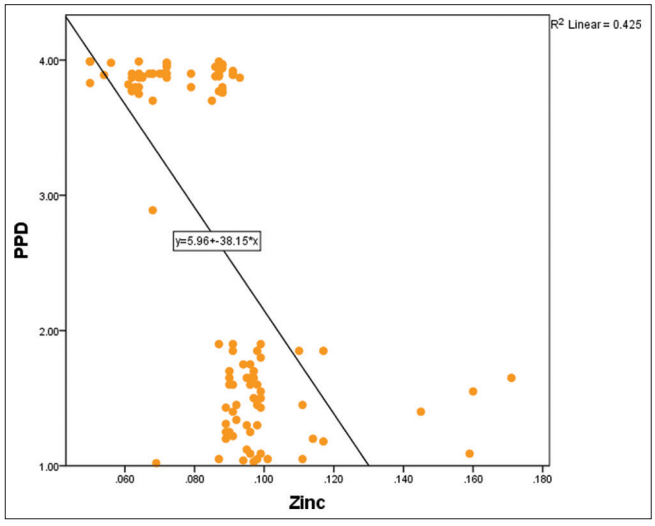
Graph 5: Correlation between serum iron (Fe) levels (mg/dl) and probing pocket depth (PPD) in periodontitis patients and normal controls Serum iron levels on correlation with PPD showed a positive correlation (Correlation coefficient=0.722)



Graph 7: Correlation between serum zinc (Zn) levels (mg/dl) and gingival index (GI) scores in periodontitis patients and normal controls Serum zinc levels on correlation with GI scores showed a statistically significant negative correlation(Correlation coefficient=−0.589)



Graph 6: Correlation between serum iron (Fe) levels (mg/dl) and clinical attachment loss (CAL) in periodontitis patients and normal controls Serum iron levels on correlation with CAL showed a positive correlation (Correlation coefficient=0.749)



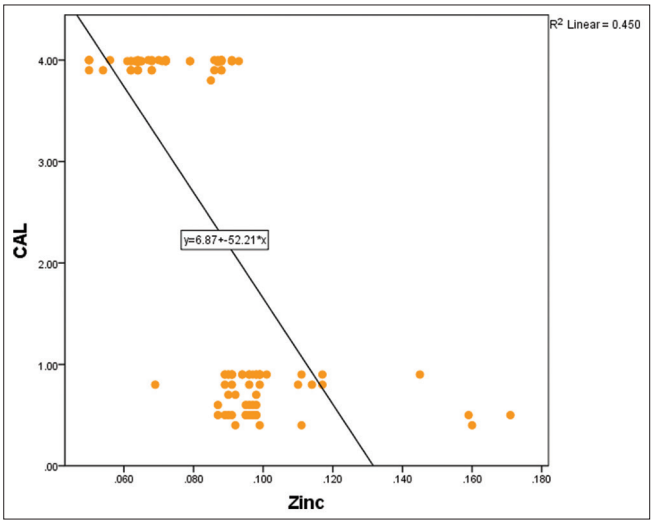
Graph 8: Correlation between serum zinc (Zn) levels (mg/dl) and probing pocket depth (PPD) in periodontitis patients and normal controls Serum zinc levels on correlation with PPD showed a statistically significant negative correlation (Correlation coefficient=−0.652)

role in immune function and resistance to infection, intervention studies utilizing trace minerals in humans are scarce. Nutrition may be important in redressing the balance between microbial challenge and the host response because it has been implicated in a number of inflammatory diseases and conditions, including, inflammatory bowel disease, rheumatoid arthritis, cardiovascular disease, and Type 2 diabetes, which have shown to be associated with periodontal disease.

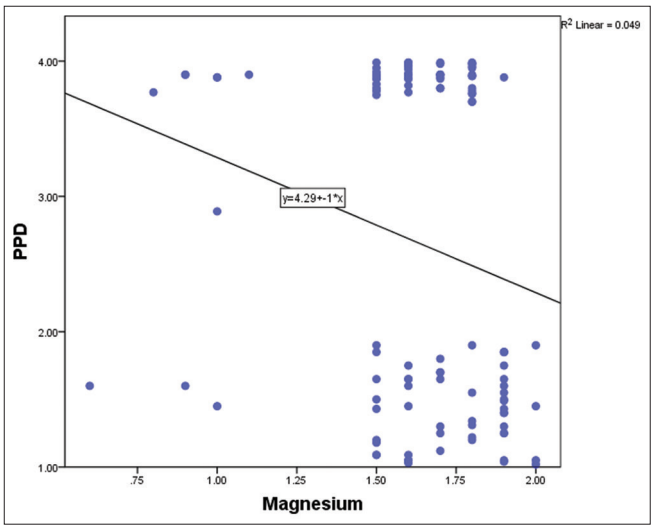
Only very few studies are available in literature pertaining to the interrelationship between serum micronutrients and chronic periodontitis. This study envisages to find out the possible link between the mineral micronutrients in chronic periodontitis.

The trace elements zinc, copper, magnesium, and iron are analyzed because they are essential components of the various antioxidant enzyme systems and play an important role in the host microbial interaction. Mineral micronutrients by combating the effects of oxidative stress help in the regenerative processes occurring in the body and also maintaining adequate immune response.

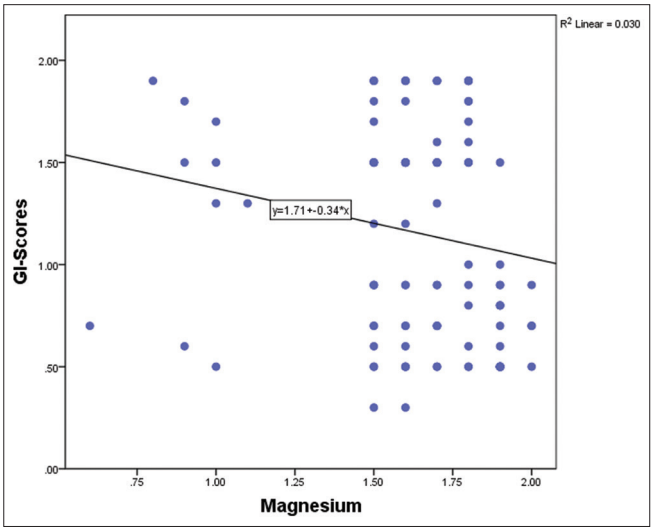
In the present study, the serum levels for micronutrients copper and iron were significantly ($P<0.001$) higher in



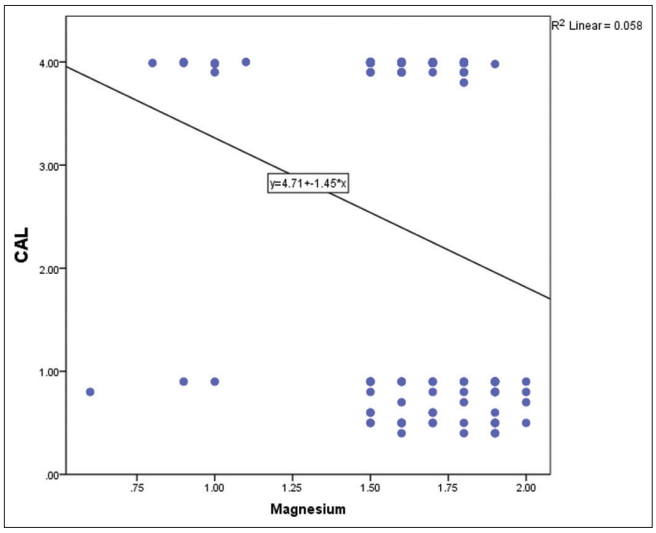
Graph 9: Correlation between serum zinc (Zn) levels (mg/dl) and clinical attachment loss (CAL) in periodontitis patients and normal controls
Serum zinc levels on correlation with CAL showed a statistically significant negative correlation (Correlation coefficient=−0.671)



Graph 11: Correlation between serum magnesium (Mg) and probing pocket depth (PPD) in periodontitis patients and normal controls
Serum magnesium levels on correlation with PPD showed a negative correlation (Correlation coefficient=−0.220) which was not statistically significant



Graph 10: Correlation between serum magnesium (Mg) levels (mg/dl) and gingival index (GI) scores in periodontitis patients and normal controls
Serum magnesium levels on correlation with GI scores showed a negative correlation (Correlation coefficient=−0.174) which was not statistically significant



Graph 12: Correlation between serum magnesium (Mg) levels (mg/dl) and clinical attachment loss (CAL) in periodontitis patients and normal controls
Serum magnesium levels on correlation with CAL showed a negative correlation (Correlation coefficient=−0.241) which was not statistically significant

the case group compared to the control group. Copper is important in the production of hemoglobin, myelin, collagen, and melanin. Copper is also essential for several proteins and enzymes that participate in iron and lipid metabolism, connective tissue synthesis, and functions of the immune and central nervous systems. Copper levels are seen to be elevated in various disease conditions which suggest a requirement of this micronutrient for the synthesis of copper-dependent regulatory proteins and enzymes in the body, required to combat the disease. Copper plays a role in several antioxidant enzyme systems especially as a part of the superoxide dismutase (SOD) family. which helps to quench superoxide free radicals. Copper ions play a role in the conversion of superoxide to hydrogen peroxide and hydroxyl radicals. Gubler et al.,[31] have shown that higher levels of copper can lead to increased oxidative stress which can cause increased periodontal tissue destruction. On the other hand, Freeland et al.,[32] have stated that elevated serum copper levels alter collagen metabolism increasing the susceptibility of the individual for chronic periodontitis. He also reported that serum copper levels are seen to be elevated during inflammation. This is said to be due to an endogenous

leukocyte mediator at the site of inflammation that acts as a feedback signal to mobilize copper from the liver. This mechanism can explain elevated serum copper levels found in chronic. Lysyl oxidase a specific monoamine oxidase, a copper metalloenzyme is involved in stabilizing collagen. Elevated levels of copper in the serum during chronic inflammation could be due to the accumulation of this enzyme in the serum.

Iron is one of the most important micronutrients involved in nutrition. It is a functional component of immunoglobulin and also helps to maintain immune functions. Iron is required for the hydroxylation of proline and lysine, and hence, severe iron deficiency can result in impaired collagen production. In the presence of Fe2+ ions, hydrogen peroxide undergoes Fenton reactions forming the most potent of all oxygen radicals, the hydroxyl radical (OH^-). Iron in the body serves as a carrier of oxygen to the tissue from the lungs by hemoglobin and also as a transport medium for electrons within cells. It is also an integral part of the various enzyme systems. Excess serum concentration of iron has been implicated in the pathogenesis of diabetes and its complications. Thomas et al.,[33] reported that elevated free iron can lead to increased formation of ROS. Harshavardhana et al.,[34] reported that iron might be an important factor in periodontal disease activity since it can enhance the growth and virulence of microorganisms in the subgingival plaque. Nutrients are required for the growth and virulence of microorganisms to overcome the host defenses of the nutrients required; iron stands as an essential element because of its necessity various stages of cell metabolism.

Serum zinc levels were found to be significantly decreased in the periodontitis patients compared to controls and the results are in agreement with the studies of Kuraner et al.,[35] Thomas et al.,[36] opined that zinc being an intracellular signaling molecule is involved in intracellular protein synthesis and cellular proliferation. Zinc deficiency can cause reduced osteoblastic activity, decreased collagen synthesis, and subdued alkaline phosphatase activity. Frithiof et al.,[37] reported an inverse correlation between serum zinc levels and alveolar bone loss. Zinc deficiency can cause reduced immune status through decreased phagocytosis, decreased NK cell activity, decreased generation of antioxidants, altered structure of α2-macroglobulin, and increased interaction with cytokines and proteases. Increased calculus formation in periodontal disease, increased permeability of the gingival epithelium for bacteria also occur in zinc deficiency (Prasad et al.),[38] Tapiero and Tewetal.,[39] reported that zinc can stabilize the structure of the cell membrane and maintain the structural integrity of SOD and the tissue concentration of metallothionein. Chronic zinc deficiency can make an organism more susceptible to oxidative stress induced tissue injury. Thus, zinc deficiency by means of immune suppression and increased oxidative stress can cause poor regenerative capacity is an individual causing predisposition to chronic periodontitis.

Magnesium plays an important role in several physiological functions and its imbalance can be associated with various pathological situations. An imbalance of magnesium may have a significant role in the pathogenesis of chronic periodontitis. Pushparani et al.,[40] stated that individuals with low serum magnesium have increased oxidative stress in conditions such as diabetes and periodontitis. On the other hand, Meisel et al.,[41] observed that reduced serum magnesium concentration was associated with enhanced inflammatory response to bacterial challenge. In addition, Guerrero-Romero and Rodriguez-Moran[42] found a strong relationship between decreased serum magnesium levels and metabolic syndromes. There is a possible interrelationship between magnesium deficiency and hyperglycemia in periodontitis patients. In the present study, statistically non-significant negative correlation between magnesium level and periodontal clinical parameters may probably be due to the exclusion of other systemic diseases including diabetes mellitus. The study by Chapple[26] observed that pro-inflammatory cascades that cause tissue damage is increased in inflammatory conditions like periodontitis and Type2 diabetes mellitus. Earlier studies by Van der Velden et al.,[43] have determined and related serum magnesium to periodontal clinical parameters.

An understanding of the levels of serum micronutrients in periodontitis patients may pave the way for therapeutic intervention studies either by supplementation or depletion and follow-up estimations of micronutrients can help in monitoring the progression of this disease and also treatment outcome.

Limitations of the study

- Apart from serum samples, the trace micronutrient levels in saliva, gingival crevicular fluid, and gingival tissue samples could also be carried out, to better understand the nature of chronic periodontitis.
- Published data on the concomitant analysis of micronutrients levels in serum, saliva, gingival crevicular fluid, and gingival tissue is scarce.
- There are numerous studies showing that proper nutrition can prevent and possibly reverse the progression of periodontal disease. Intervention studies are needed to further understand the dietary intake of the patients, the need for dietary supplements and also the host inflammatory response for the better treatment outcome and for ameliorating patients with periodontitis.
- A much larger sample size is needed for a better interpretation and appropriate conclusion.

CONCLUSION

1. The serum levels of zinc were significantly reduced in chronic periodontitis patients as compared to healthy controls
2. The serum levels of copper and iron were significantly higher in chronic periodontitis patients
3. There serum magnesium level was slightly decreased in chronic periodontitis patients as compared to normal controls
4. Serum copper and iron showed a significant positive correlation with periodontal clinical parameters (gingival index, PPD, and clinical attachment loss)
5. Serum zinc and magnesium levels showed negative correlation with periodontal clinical parameters (gingival index, PPD, and clinical attachment loss)
6. The present study supports and extends the view that the assessment of the micronutrient can serve as possible biomarkers or indicators for an inflammatory condition like chronic periodontitis.

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