

Effect of Weight Reduction on the Serum Adiponectin and Tumor Necrosis Factor- α Levels and the Clinical Parameters of Obese Patients with and without Periodontal Disease

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ABSTRACT

Objective: The objective of the current study was to assess the impact of weight reduction on the attenuation of obesity-related periodontal inflammation.

Methods: This study was conducted enrolling 60 obese subjects. They were divided into three groups of 20 each. Group 1-healthy group, Group 2-gingivitis group, and Group 3-periodontitis group. The body mass index and waist/hip ratio, periodontal parameters such as plaque index, bleeding index, full mouth periodontal probing depth (PPD) using the University of North Carolina 15 (UNC 15) probe and full mouth clinical attachment loss (CAL) with cemento-enamel junction as the reference using UNC 15 probe was evaluated at baseline and after the attainment of $\geq 10\%$ weight loss by the subjects. Adiponectin and tumor necrosis factor-alpha (TNF- α) levels were measured in the serum at baseline and after attainment of $\geq 10\%$ reduction in weight in a period of 3–18 months.

Results: Adherence to weight reduction program until the achievement of $\geq 10\%$ reduction in body weight resulted in statistically significant ($P < 0.0001$) elevated serum adiponectin and reduced serum TNF- α levels in all three groups. Furthermore, elevations of adiponectin following weight reduction showed significant negative correlations with PPD in all the three groups and in patients with periodontitis, (Group 3) serum adiponectin levels showed significant negative correlations ($P = 0.0001$) with CAL in Group 3.

Conclusions: Controlling obesity presents a good opportunity to alleviate the burden of periodontal disease. Simple weight reduction programs with diet and exercise-related lifestyle modifications may be an efficacious and barrier-free option.

KEYWORDS: Adiponectin, gingivitis, obesity, periodontal disease, tumor necrosis factor-alpha

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INTRODUCTION

Obesity is a complex multifactorial chronic disease that develops from an interaction of genotype and the environment.^[1] The World Health Organization (WHO)^[2] has recognized obesity as a predisposing factor to major chronic diseases ranging from cardiovascular disease to cancer. It has been suggested that obesity contributes to an overall systemic inflammatory state through its effect on metabolic and immune parameters, thereby increasing susceptibility to periodontal disease.^[3,4] A number of studies have reported an association between obesity and periodontal

disease in both animal models and humans.^[5-7] Several epidemiological studies and controlled clinical trials have also implicated the association of obesity and periodontitis.^[8] Khader *et al.* in their study showed that overweight individuals had double the incidence of periodontitis while obese individuals had triple

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the incidence of periodontitis, thus demonstrating a dose-response relationship.^[9]

These findings suggest that periodontal disease may be exacerbated by conditions associated with obesity and that obesity may be a risk factor for periodontitis.^[10,11]

The biological mechanisms for the association of obesity and periodontitis most likely involve adipose tissue-derived cytokines and hormones. Adipose tissue produces various cytokines and hormones, collectively called adipokines, which may modulate periodontitis.^[3,4] These released adipokines are leptin, tumor necrosis factor-alpha (TNF- α), interleukin-6 (IL-6), IL-8, monocyte chemoattractant protein-1, and adiponectin.^[12]

Adiponectin is mainly produced by adipocytes. The plasma levels decrease in obese individuals as compared to normal-weight individuals.^[13] It also has anti-inflammatory, vasoprotective, and antidiabetic effects. These effects occur due to suppression of TNF- α and IL-6, along with induction of IL-1 receptor antagonist.^[14]

In spite of the various evidence available, the role of obesity on the periodontal health is still not very clear. The association between obesity and periodontitis could be, at least in part, due to common lifestyle characteristics that make subjects more prone to both obesity and periodontal disease. However, maintaining normal body weight, eating a well-balanced diet and engaging in physical activity have been shown to reduce the severity of periodontitis.^[15,16] Thus, all health professionals, including the dental team, can provide an important service to patients with obesity by educating them about the risk of periodontal disease and the importance of proper oral hygiene.

To our knowledge, there is sparse literature estimating the relationship between adiponectin and TNF α levels in the serum of obese individuals suffering from periodontal disease before and after weight loss. Hence the present investigation evaluates the impact of weight reduction on the adipokine, adiponectin and TNF- α levels in the gingival crevicular fluid and thereby on the periodontal status of obese patients with and without periodontal disease.

METHODS

This study was conducted to assess the association between obesity and periodontal disease in the Indian population. The study was conducted at the M. R. Ambedkar Dental college and Hospital, Bengaluru. The participants were referred from Bangalore-based health clubs promoting weight loss through lifestyle modifications. All the study participants signed an

informed consent form and the study was approved by the Institutional Ethics Committee. (Ref no: MRADCandH/ECIRB/024/2010-11). All the parameters were evaluated by the principal investigator. Based on the available literature on serum adiponectin levels in periodontal disease the difference of 2.1 $\mu\text{g/ml}$ after weight loss among participants, the sample size was estimated to be 20 (inclusive of attrition 10%) to detect the 2.1 $\mu\text{g/ml}$ as a significant difference.^[12] The sample size estimated keeping 80% statistical power and 5% level of significance overall, in a three group study total of 60 subjects are recruited for testing research hypothesis. The subjects were divided into three groups of 20 each as.

- GROUP 1 - Periodontally healthy obese patients
- GROUP 2 – Obese patients with gingivitis
- GROUP 3 - Obese patients with periodontitis.

EXCLUSION CRITERIA

Exclusion criteria were patients with:

1. History of underlying systemic diseases
2. History of periodontal treatment in the past 6 months
3. Any medication affecting periodontal health
4. History of tobacco chewing
5. Current and former smokers
6. Pregnant and lactating mothers
7. Patients on steroid therapy and oral contraceptives.

INCLUSION CRITERIA

Obese subjects

1. Body mass index (BMI) $\geq 30 \text{ kg/m}^2$
2. Not suffering from any other obesity-related diseases or other systemic diseases
3. Not on any medications.

Periodontally healthy subjects

1. Clinically healthy periodontium (presence of $\leq 5\%$ sites with bleeding on probing)
2. Probing pocket levels of $\leq 3 \text{ mm}$
3. No or incipient attachment loss ($\leq 2\text{mm}$).

Gingivitis subjects

1. Patients with gingival inflammation
2. Presence of bleeding on probing $\geq 50\%$ of sites
3. Patients with ≥ 20 teeth excluding third molars with minimal or no attachment loss and probing depth (PD) of $\leq 3 \text{ mm}$.

Periodontitis subjects

1. Patients with bleeding on probing $\geq 80\%$ of sites
2. Patients with ≥ 20 teeth excluding the third molars with at least 8 teeth showing $\geq 3 \text{ mm}$ of clinical attachment loss (CAL) and $\geq 5 \text{ mm}$ of probing pocket depth.

Participants included in the study were advised on oral hygiene techniques to manage their condition.

Furthermore, participants requiring immediate interventions for gingivitis and periodontitis were excluded from the study.

In obese individuals the BMI was calculated by measuring the weight to the nearest 0.1 kg, and measuring the height to the nearest 0.5 cm, (kilograms per meter squared).

$$\text{BMI} = \frac{\text{Weight in kg}}{\text{Square of Height in meters}}$$

$$\text{BMI} = \frac{\text{Kg}}{(\text{m})^2}$$

Waist-hip ratio (W/H) was calculated by measuring the minimal abdominal circumference between the xiphoid process and the iliac crests (waist) with participants standing and breathing normally, this was divided by the hip circumference, measured on the greater trochanters.

These measurements were done before and after weight reduction. The patients were also subjected to routine blood investigations and lipid profile.

Periodontal parameters, namely bleeding index (BI), plaque index (PI), full mouth periodontal PD (PPD) using the University of North Carolina 15 (UNC 15) probe and full mouth CAL with cemento-enamel junction as the reference using the UNC 15 probe was evaluated at baseline and after the attainment of $\geq 10\%$ weight loss by the subjects.

A 2 ml sample of peripheral venous blood collected by venipuncture was centrifuged and serum separated. The collected serum samples were stored at -70°C for further evaluation. The serum samples were collected at two-time intervals, one at baseline and the other after attainment of $\geq 10\%$ weight reduction in a period of 3–18 months. The stored serum samples were then evaluated for serum adiponectin and TNF- α using commercially available enzyme-linked immunosorbent assay kit (RayBiotech, Inc. 3607 Parkway Lane, Suite 200, Norcross GA 30092) at baseline and after attainment of the primary endpoint.

STATISTICAL ANALYSIS

Results are presented as mean \pm standard deviation and proportions are presented as percentages. Analysis of variance was used to compare means across the three groups of the study. *t*-tests were used to compare means between two groups. Pearson's correlation was used to assess the relationship between the concentrations of adiponectin and periodontal parameters. Level of significance was set at 0.05. The tests were conducted using SSP version 19.0 (IBM, Bangalore, Karnataka, India). All the study participants signed an informed

consent form, and the study was approved by the Institutional Ethics Committee.

RESULTS

The study included a total of 60 participants. All the study participants achieved the primary endpoint of $\geq 10\%$ reduction in body weight in a period of 3–18 months postenrollment. Table 1 presents the demographic profiles and the baseline characteristics, the values are represented as mean of 20 participants, of the age, body weight, BMI, and W/H ratio of the study participants. Participants in all the three groups were adherent to weight reduction programs and attained significant reductions in weight in 3–18 months from the baseline.

The change in the body weight before and after $\geq 10\%$ of weight reduction is presented in Table 2. There is a significant change in body weight in all the three groups ($P < 0.05$), the values are represented as mean of 20 participants.

The distribution of BMI in all the three groups before and after $\geq 10\%$ of weight reduction is presented in Table 3, the values are represented as mean of 20 participants. The comparison of the mean BMI before and after weight reduction showed a statistically significant changes in the mean BMI between the groups (Group 1 $P = 0.0001$, Group 2 $P = 0.0001$, and Group 3 $P = 0.001$).

Table 1: Demographic profiles and the baseline characteristics of age, body weight, body mass index, waist/hip ratio of the study participants

	Group 1 (n=20)	Group 2 (n=20)	Group 3 (n=20)	P
Age (years)	35.5 \pm 7.97	37.9 \pm 10.84	39.45 \pm 8.78	0.404
Body weight	79.25 \pm 5.00	83.33 \pm 7.94	91.25 \pm 13.05	0.001
BMI	32.05 \pm 2.16	32.42 \pm 2.54	36.23 \pm 5.13	0.001
Waist to hip ratio	0.93 \pm 0.069	0.93 \pm 0.103	0.96 \pm 0.126	0.530

Mean of 20 participants in each group. BMI=Body mass index

Table 2: Reductions in body weight from baseline

Groups	Body weight at baseline	Body weight at endpoint	Percentage weight loss	P
Group 1	79.25	65.42	17.45	0.0001
Group 2	83.33	69.89	16.12	0.0001
Group 3	91.25	76.82	15.81	0.001

Mean of 20 participants in each group

Table 3: Reductions in body mass index from baseline

Groups	BMI at baseline	BMI at endpoint	Percentage changes	P
Group 1	32.05 \pm 2.16	32.42	18.28	0.0001
Group 2	32.42 \pm 2.54	29.89	16.40	0.0001
Group 3	36.23 \pm 5.13	32.82	15.89	0.001

Mean of 20 participants in each group. BMI=Body mass index

The distribution W/H ratio before and after weight reduction is as shown in Table 4, the values are represented as mean of 20 participants. The comparison of the mean W/H ratio before and after weight reduction were not so significant in all the three groups (Group 1 $P = 0.601$, Group 2 $P = 0.716$, and Group 3 $P = 0.767$).

As shown in Table 5, statistically significant changes before and after weight reduction were noted with respect to BI, PI, PD and CAL in all three groups.

Furthermore, statistically significant changes were observed in the serum adiponectin and TNF α levels in all three groups before and after weight reduction. The serum adiponectin levels showed an increase in the levels following weight reduction, whereas TNF α levels decreased following weight reduction as shown in Table 6.

The Pearson's co-relation showed a significant negative co-relation of adiponectin with probing pocket depth in all the three groups, as shown in Table 7.

In patients with periodontitis, serum adiponectin levels showed significant negative correlations ($P = 0.0001$) with CAL as shown in Table 8.

DISCUSSION

The association of obesity and periodontal disease is relatively well-established. Considering the high

prevalence of obesity, periodontal disease and the resource limitations in Indian settings, it is important to assess and develop obesity-control measures that are easy on the cost and resource barriers. In this study, we have evaluated the impact of weight reduction on adiponectin and TNF- α levels in the serum of obese patients with and without periodontal disease.

An important aspect of this study was that there was no attrition. All the 60 participants enrolled for the study completed it, this can be attributed to the high motivational levels of the participants to adhere to the weight reduction.

On the premise of the findings of a 3-year weight loss study by Madsen *et al.*, outcome measures (adiponectin and TNF- α) were assessed after achieving $\geq 10\%$ reduction in weight.^[12] Madsen *et al.* note that long-term weight loss (3 years) must exceed 10% for achieving significant improvements in adiponectin levels. Although the current study noted these improvements in inflammatory markers in a period of 3–18 months, it may be important for participants to continue on the weight reduction programs for longer periods to consistently reduce the pro-inflammatory effects of obesity. The percentage weight loss in all the three groups was statistically significant.

The evidence linking obesity and the incidence and severity of periodontal disease has grown in recent years.^[9,10,15-19] The risk of periodontitis is associated to be increased with increased BMI, waist circumference (abdominal obesity), serum lipid levels, and the percentage of subcutaneous body fat. Francis *et al.* showed a 30% increased risk for periodontitis per 1 kg/m² increase in BMI. They concluded that the periodontal disease was associated with increased BMI establishing a link between obesity and periodontitis.^[20] Several studies showed similar results

Table 4: Reductions in waist/hip ratio from baseline

Groups	W/H at baseline	W/H at endpoint	Percentage changes	P
Group 1	0.93 \pm 0.06	0.92 \pm 0.06	1.0	0.601
Group 2	0.93 \pm 0.10	0.93 \pm 0.07	0	0.716
Group 3	0.96 \pm 0.12	0.95 \pm 0.09	1.04	0.767

Mean of 20 participants in each group. W/H=Waist/hip

Table 5: Changes in periodontal parameters at baseline and after $\geq 10\%$ weight reduction

	Mean \pm SD at baseline	Mean \pm SD at endpoint	Difference from baseline (%)	P
PI				
Group 1	0.19 \pm 0.06	0.14 \pm 0.04	26.31	0.004
Group 2	1.58 \pm 0.22	1.29 \pm 0.20	18.35	0.0001
Group 3	1.51 \pm 0.30	1.11 \pm 0.23	26.49	0.0001
PD				
Group 1	0.99 \pm 0.35	0.69 \pm 0.21	30.30	0.002
Group 2	84.17 \pm 9.85	68.78 \pm 5.87	18.28	0.0001
Group 3	84.05 \pm 8.49	69.85 \pm 6.26	16.89	0.0001
BI				
Group 1	2.00 \pm 0.53	1.57 \pm 0.39	21.5	0.006
Group 2	2.59 \pm 0.25	2.27 \pm 0.26	12.35	0.0001
Group 3	3.65 \pm 0.35	2.97 \pm 0.24	18.63	0.0001
Clinical attachment level				
Group 3	1.66 \pm 0.65	0.85 \pm 0.47	48.79	0.0001

Mean of 20 participants in each group. SD=Standard deviation, BI=Bleeding index, PD=Probing depth, PI=Plaque index

Table 6: Changes in serum adiponectin and tumour necrosis factor α levels at baseline and after >10% weight reduction

Groups	Mean \pm SD levels at baseline	Mean \pm SD levels at endpoint	Difference from baseline (%)	P
Adiponectin in Serum				
Group 1	869.17	947.43	8.26	0.0001
Group 2	934.85	1013.71	7.78	0.0001
Group 3	894.60	1080.02	17.165	0.0001
TNF- α in serum				
Group 1	768.15	717.41	6.60	0.0001
Group 2	814.64	757.27	7.04	0.0001
Group 3	756.11	707.58	6.41	0.0001

SD=Standard deviation, TNF- α =Tumour necrosis factor α **Table 7: Pearson's correlation of serum adiponectin levels and probing pocket depth - before and after weight reduction**

	Serumadiponectin and PPD			
	Before weight reduction		After weight reduction	
	R	P	R	P
Group 1	-0.078	0.0001	-0.375	0.0001
Group 2	-0.001	0.0001	-0.003	0.0001
Group 3	-0.026	0.0001	-0.125	0.0001

PPD=Probing pocket depth

Table 8: Pearson's correlation of serum adiponectin levels and clinical attachment level - before and after weight reduction

	Serumadiponectin and CAL			
	Before weight reduction		After weight reduction	
	R	P	R	P
Group 3	-0.050	0.0001	-0.002	0.0001

CAL=Clinical attachment loss

correlating BMI to oral health.^[21-23] These studies suggest a decrease in the BMI may have a positive impact on periodontal health. In this study, the comparison between the mean BMI before and after weight reduction showed a statistically significant change ($P < 0.05$) among all the three groups. This reduction in the BMI might decrease the inflammatory burden and hence have a significant effect on periodontal health. The percentage difference in the W/H before and after weight reduction in all the three groups were not statistically significant, Group 1 1.0% with $P = 0.601$, Group 2 0%-0% $P = 0.716$, and Group 3 -1.04% with a $P =$ of 0.767.

In this study, the PI, BI, PD, and CAL show a statistically significant change before and after weight reduction [Table 5]. The changes in the periodontal parameters without any intervention and just maintaining good oral hygiene and reemphasizing on the oral hygiene

measures indicate that the mere reduction in the weight might bring about some reduction in the inflammatory burden on the periodontium.

In the current study, there was an increase in the serum levels of adiponectin and a decrease in the serum TNF α levels after weight reduction of $\geq 10\%$. This showed a significant correlation with probing pocket depth in all the three groups (Group 1, Group 2, Group 3 all showed a $P = 0.0001$) and CAL in Group 3 ($P = 0.0001$). Thus, it appears that control of obesity can through correcting inflammatory molecules could have significant effects on clinical periodontal parameters.

A negative feedback mechanism can be suggested because in obesity, plasma adiponectin levels are lower despite that adipose tissue is the only tissue of its synthesis. Weight loss would result in at least transient disinhibition, therefore an elevation of plasma adiponectin. Recent studies have shown that the expression of adipogenic genes was suppressed in the development of obesity and diabetes mellitus in mice argues for the existence of a feedback inhibitory pathway.^[24]

This negative feedback mechanism might explain the increase in the adiponectin levels in all the three groups after weight reduction in our study. Moreover, this increase in adiponectin levels had an inverse relation to the PPD in all the three groups and CAL in the Group 3.

Furthermore, there was a change in the serum TNF α levels in all the groups after weight reduction in the study. Puglisi *et al.*^[25] in their study stated that following weight reduction, there is a decrease in TNF α and C reactive protein levels and increased adiponectin levels, which is in accordance with the current study. Hence, decrease in the levels TNF- α and increase in level of adiponectin following weight reduction may effectively reduce the risk for chronic periodontitis among obese individuals.

Results of this study indicate that there might be an association between the inflammatory effects of obesity and periodontal disease. Controlling obesity seems to have definitive positive impact on reducing the burden of periodontal disease. Ciao *et al.* noted that many obese individuals who might benefit from weight loss treatment perceive multiple barriers (including cost and time) to seek treatments and call for encouragement of less intensive treatments that are seen as more barrier-free.^[26] Results of the current study indicates that simple weight reduction programs with diet and exercise-related lifestyle modifications may be one such barrier-free option. In another recent study, Akram *et al.* noted a refreshing and reassuring observation that family physicians are generally aware of the associations of obesity and periodontal disease and show a positive attitude to refer obese patients

to weight management clinical programs.^[27] Results of the current study may add more confidence and fillip for further research on this topic.

CONCLUSION

The results of the current study indicate that controlling obesity presents a good opportunity to alleviate the inflammatory burden of periodontal disease. Simple weight reduction programs with diet and exercise may go a long way in controlling a multifactorial disease like periodontitis.

In spite of our planned efforts, there are certain shortcomings in the conduct of the study. Use of the worldwide criteria of BMI guidelines as recommended by the WHO for the segregation of the population into obese and nonobese. The difference of opinion exists among the researchers with the use of BMI among the Asian population; anyways we have still considered BMI as the measure in our study along with W/H ratio as there are no other standard measures. Since our participants were highly motivated, our results may be partially due to the Hawthorne effect.

FUTURE DIRECTIONS

Further research with prospective cohort studies can be conducted with multicenter trials to evaluate the impact of lifestyle modifications on periodontal health in obese participants and their influence on the inflammatory markers. This would also be helpful in better understanding of the role of adiponectin in the pathogenesis of periodontitis.

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CONFLICTS OF INTEREST

There are no conflicts of interest.

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