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INFLUENCE OF SMOKING CESSATION ON PERIODONTAL HEALTH: A STRATEGIC REVIEW

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ABSTRACT

Smoking is one of the major risk factor in the development and progression of periodontal disease. Recent evidences supports that smoking may also interact with other factors including genetics and diabetes potentiating periodontal breakdown. Hence quitting smoking is absolutely essential for the prevention of diseases, health enhancement and improving the healing potential before beginning treatments of diseases, including periodontitis. This literature review aims to give an insight about the influence of smoking cessation on oral micro flora, gingival blood flow, gingival crevicular fluid, plasma constituents, enzyme activity, immunologic function, bone loss and healing potential. Periodontal disease progression and its response to periodontal therapy and the success rate involved in implant placement subsequent to quitting the habit of smoking is also discussed in this review

Key Words: Bone loss, Periodontium, Smoking cessation, Wound healing

INTRODUCTION

"Giving up smoking is the easiest thing in the world. I know because I've done it thousands of times"- Mark Twain. Tobacco smoking is an addictive habit and has been practiced in one form or another since ancient times. Smoking harms virtually every organ in the body. Tobacco and various hallucinogenic drugs were smoked all over the Americas as early as 5000 BC in shamanistic rituals and originated in the Peruvian and Ecuadorian Andes. Many ancient civilizations, such as the Babylonians, Indians and Chinese, burnt incense as a part of religious rituals, as did the Israelites and the later Catholic and Orthodox Christian churches.[1]

One of the first published medical reports on the effects of tobacco appeared in 1859. It was based on a study of 68 patients in a hospital in Montpellier, France, who had cancer of lips, tongue, tonsils and other parts of the mouth. The authors noted that all of the patients used tobacco and that 66 of them smoked short- stemmed clay pipes. In the mid-1950s, the American Cancer Society and British Medical Research Council each conducted large scale epidemiological studies. Both groups independently reported that studies showed a higher death rate among cigarette smokers than nonsmokers.[1]

More than 40 years have passed since 1964 US Surgeon General Report linked cigarette smoking to lung cancer and cardiovascular disease. Since then, the list of smoking related health effects has grown and cigarette smoking is recognized as the leading preventable cause of death in the world. The following year federal legislation was passed requiring all cigarette packages to carry health hazards warning labels. Since the Surgeon General's Report, the ADA has been in its opposition to use of any type of tobacco and has supported and promoted smoking cessation efforts by dentists since 1981.[2]

As a result of increased public awareness of the negative effects of smoking, the percentage of adult smokers in US has declined substantially over the past 20 years to approximately 21% in 2005. However smoking is on the rise in developing nations and on global level about 47% of the male adult population smokes. It is responsible for more than 5 million deaths each year and the death toll from tobacco is expected to climb to more 8 million people per year within next 25

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years. It is estimated that eventually 50% of all smokers will be killed by direct or indirect effects of tobacco. As in 2002, some 1.22 billion people smoked. It was predicted that by 2010, 1.45 billion people will smoke and 1.5 to 1.9 billion by 2025.[2]

It has been estimated, there are 182 million (16.6%) smokers in India.[3] Among tobacco users, 34% smoke Bidis, 31% are regular cigarette smokers, and 35% use smokeless tobacco.[4] Bidis are chocolate, mint, or fruit flavoured tobacco cigarette hand-rolled in tendu or temburni leaf and are common throughout India and southeast Asia and are especially appealing to young smokers. The prevalence of smoking among 13-15 year old school going students in India ranges from 19.7-34.5%, even the lowest was considerably higher than the global median of current cigarette smoking (13.9%).[5]

Many teenagers and younger children inaccurately believe that experimenting with smoking or even casual use will not lead to any serious dependency. In fact, the latest research shows that serious symptoms of addiction such as having strong urges to smoke, feeling anxious or irritable, or having unsuccessfully tried not to smoke can appear among youths within weeks or only days after occasional smoking first begins.[6] The average smoker tries their first cigarette at age 12 and may be a regular smoker by age 14.[7,8] Every day, more than 3,500 kids try their first cigarette and about 1,000 other kids under 18 years of age become new regular, daily smokers.[9] Almost 90% of youths that smoke regularly report seriously strong cravings, and more than 70% of adolescent smokers have already tried and failed to quit smoking.[10]

For many years, smoking has been linked to lung disease, cancer, cardiovascular disease, and poor pregnancy outcomes, such as miscarriage and low birth weight. Over the past two decades, it has also been recognized that smoking is associated with periodontal disease. The fact that smoking is both a strong and a common risk factor highlights the significance of smoking cessation. This literature reviews the role of smoking cessation on periodontal health.

EFFECT OF SMOKING CESSATION ON ORAL FLORA

To gain insight into the influence of smoking on the micro flora, Michiya Kubota1 & Mariko Tanno-Nakanishi (2011) conducted a study on Japanese patients with periodontitis, and they observed a significant association between bleeding on probing and the detection of Campylobacter rectus, Prevotella intermedia, and smoking. Prevalence of Campylobacter rectus was higher in smokers than non-smokers. They concluded that the analysis of the subgingival microbial flora in smokers and non-smokers with chronic periodontitis suggests a relevant association between smoking and colonization by the specific periodontal pathogens including Campylobacter rectus.[11]

It is established that bacterial consortia within the subgingival microbiome play a critical role in the etiology of chronic periodontitis. Although tobacco smoking has been shown to preferentially enrich this microbiome for pathogenic species,[12,13] it is not known if smoking cessation is capable of reversing this pathogenic colonization, since current evidence is based only on cross-sectional comparisons of former and current smokers.[14,15]

The subgingival microbiome is complex, with several uncultivated and as-yet-unrecognized members,[16,17] and hence, cultivation-based approaches have not been able to comprehensively examine the effects of smoking cessation on this ecosystem. Suzanne L. Delima et al. longitudinally examined the effect of smoking cessation on the prevalence and levels of selected subgingival bacteria using molecular approaches for bacterial identification and enumeration. Subgingival plaque was collected from 22 smokers at the baseline and 12 months following periodontal nonsurgical management and smoking cessation counseling. The prevalence and abundance of selected organisms were examined using nested PCR and multiplexed bead-based flow cytometry. Eleven subjects successfully quit smoking over 12 months (quitters), while 11 continued to smoke throughout (smokers). Smoking cessation led to a decrease in the prevalence of Porphyromonas endodontalis and Dialister pneumosintes at 12 months and in the levels of Parvimonas micra, Filifactor alocis, and Treponema denticola. Smoking cessation also led to an increase in the levels of Veillonella parvula. Following nonsurgical periodontal therapy and smoking cessation, the subgingival microbiome is recolonized by a greater number of health-associated species and there are a significantly lower prevalence and abundance of putative periodontal pathogens. The results from this study provide evidence that following nonsurgical therapy and smoking cessation, the subgingival microbiome undergoes a compositional shift resulting in colonization by health-associated species and a significantly lower prevalence and abundance of pathogens than those observed in smokers who receive nonsurgical therapy but continue to smoke. This shift toward a health-compatible profile may contribute to the clinical improvements in periodontal status associated with smoking cessation. The results also indicate that there is very little alteration in the microbiome following periodontal therapy in continuous smokers, suggesting an urgent need for smoking cessation counseling in conjunction with active periodontal therapy.[18]

Fullmer S C investigated longitudinally, if smoking cessation altered the composition of the subgingival microbial community, by means of a quantitative, cultivation-independent assay for bacterial profiling. The microbial community in smokers was similar to baseline, while quitters demonstrated significantly divergent profiles. Changes in bacterial levels

contributed to this shift. These findings reveal a critical role for smoking cessation in altering the subgingival biofilm and suggest a mechanism for improved periodontal health associated with smoking cessation.[19]

INFLUENCE OF SMOKING CESSATION ON GBF AND GCF

The gingival blood flow (GBF) and the gingival crevicular fluid (GCF) are well-known markers of gingival health and have been used in many studies (Persson et al. 1999, Meekin et al. 2000).[20,21] Smoking has a long term chronic effect, impairing the vasculature of the periodontal tissues rather than a simple vasoconstrictive effect following a smoking episode. The suppressive effect on the vasculature can be observed through less gingival redness, lower bleeding on probing and fewer vessels visible clinically and histologically. This also has relevance to the healing response with impairment of revascularization.

Evaluation of the gingival blood flow in smokers and nonsmokers with periodontal disease before and after surgical periodontal treatment was performed. Gingival blood flow and gingival vascular conductance (VC) decreased significantly pre and post operatively in response to smoking. Cold pressor test evoked significant decrease in vascular conductance in smokers and blood pressure was significantly high in nonsmokers.[22]

McLaughlin W.S et al (1993) observed a strong evidence of an increase in GCF flow rate of short duration following smoking. This increase in GCF flow rate could be attributed to a reflex response to irritation or stimulation from tobacco smoke particles as observed by Pangborn and Sharon (1971) or a raised intra oral temperature.[23]

To determine the effect of smoking cessation on gingival blood flow (GBF) and gingival crevicular fluid (GCF), sixteen male smokers with no clinical signs of periodontal and systemic diseases, were recruited. The experiment was performed before (baseline) and at 1, 3 and 5 days, and at 1, 2, 4 and 8 weeks after smoking cessation. The status of smoking and smoking cessation was verified by exhaled carbon monoxide (CO) concentration, and by serum nicotine and cotinine concentrations. A laser Doppler flowmeter was used to record relative blood flow continuously, on three gingival sites of the left maxillary central incisor. The GCF was collected at the mesio- and disto-labial aspects of the left maxillary central incisor and the volume was calculated by the Periotron 6000s system. The same measurements except for the GBF were performed on 11 non-smoking controls. The study reported eleven of 16 smokers successfully completed smoking cessation for 8 weeks. At 1 day after smoking cessation, there was a significantly lower CO concentration than at baseline. Also, nicotine and cotinine concentrations markedly decreased at the second measurement. The GBF rate of smokers was significantly higher at 3 days after smoking cessation compared to the baseline. While the GCF volume was significantly increased at 5 days after smoking cessation compared to the baseline, it was significantly lower than that of non-smokers until two weeks after smoking cessation. Hence the study concluded gingival microcirculation recovers to normal in the early stages of smoking cessation, which could activate the gingival tissues metabolism/remodeling, and contribute to periodontal health.[24]

A group of 27 subjects on a Quit-smoking programme were examined by Nair P et al, to determine the changes in gingival health over a 4–6-week period. The bleeding on probing with a constant force probe increased from 16% of sites to 32% of sites, despite improvements in the subjects' oral hygiene. Hence there was a two-fold increase in bleeding on probing after quitting smoking. This suggest that the interference of smoking with this property of the periodontal tissues is not due to a vasoconstrictive action (from nicotine), but a result of a more profound influence on the vasculature and cellular metabolism (Palmer et al. 1999, Meekin et al. 2000).[20,25]

INFLUENCE OF SMOKING CESSATION ON PLASMA CONSTITUENTS AND ENZYME ACTIVITY

In order to study effects of cigarette smoking and smoking cessation on plasma constituents and enzyme activities related to oxidative stress, 1255 smokers and 524 healthy non-smokers were investigated in terms of plasma levels of lipoperoxides (LPO), nitric oxide (NO), vitamin C (VC), vitamin E (VE) and beta-carotene (beta-CAR). Additionally, erythrocytes were examined to determine the level of LPO, the activities of superoxide dismutase (SOD), catalase (CAT) and glutathione peroxidase (GSH-Px). The results showed that, when compared with the average values of the nonsmoker group, the average plasma values of LPO, NO and the average erythrocyte value of LPO in the smoker group were significantly increased ($P < 0.001$), while the average plasma values of VC, VE, beta-CAR, and the average erythrocyte activities of SOD, CAT, GSH-Px were significantly decreased ($P < 0.001$). A linear regression and correlation analysis for 65 male smokers who were all 40 years old showed that with longer smoking duration and greater daily smoking quantity, the plasma values of LPO, NO and the erythrocyte value of LPO were elevated, while the plasma values of VC, VE, beta-CAR and erythrocyte values of SOD, CAT, GSH-Px were decreased. In a group of 73 smokers who stopped smoking completely for six months, the average plasma values of LPO, NO and the average erythrocyte value of LPO decreased, although they were still significantly higher than those in the matched non-smoker group ($P < 0.05$). Additionally, the average plasma values of VC, VE, beta-CAR and the average erythrocyte values of SOD,

CAT, GSH-Px increased, although they were still significantly lower than those in the matched non-smoker group. However, after smoking cessation for one year the above average values were not significantly different from those in the matched non-smoker group. This finding indicates that the markedly increased oxidative stress in smokers might gradually return to normal but only after a long period of smoking cessation. Hence in the bodies of smokers a series of free radical chain reactions were gravely aggravated, the dynamic balance between oxidation and antioxidation was seriously disrupted, and oxidative stress was clearly exacerbated, which is closely related to many disorders or diseases in smokers. The study underscored the need, urgency and importance of complete smoking cessation.[26]

SMOKING CESSATION AND IMMUNE FUNCTION

Association between cigarette smoking and the depression of immune function were investigated by studies of 35 subjects before, and three months after, they had ceased to smoke cigarettes. The study included tests of natural killer cell (NK) activity against several target cells and the measurement of immunoglobulin levels in sera and saliva. Similar tests were conducted on 29 control subjects who continued to smoke. The result indicated a significant decrease in lymphocyte counts and a significant increase in NK activity against cultured melanoma cells in subjects who ceased smoking. Serum IgG and IgM levels rose significantly in those who ceased smoking cigarettes, but there was no change in IgA levels. Similar increases in immunoglobulin levels (IgA and IgG) in mucosal secretions (saliva) were noted after cessation of smoking. The NK activity and immunoglobulin levels of smokers who continued to smoke did not show significant changes. These results were consistent with the reversal of changes in immune function associated with smoking.[27]

Meliska C J et al examined group of 28 healthy, white, male, light-to-moderate smokers, 21 to 35 years of age, who were offered a financial inducement to abstain from smoking for 31 days. A matched control group of 11 smokers were paid to continue smoking during the same period. Nonspecific parameters of immune system function were monitored before and at various times after smoking abstinence. Abstinence increased natural killer cell cytotoxic activity but did not alter mitogen-induced T-lymphocyte proliferation as measured by responses to concanavalin A or phytohemagglutinin. Serum cortisol concentrations also decreased after smoking cessation; however, changes in immune function were not correlated with serum cortisol change, nor with indices of smoking such as plasma nicotine and cotinine levels. Responses to concanavalin A and phytohemagglutinin were positively correlated with change in self-reported alcohol ingestion during smoking abstinence. Hence the elevation in natural killer cell cytotoxic activity is detectable within one month of smoking cessation, even in light-to-moderate smokers.[28]

To determine the effectiveness of smoking cessation on natural killer (NK) activity of peripheral blood lymphocytes, Ioka A et al conducted a prospective study on 27 Japanese subjects who participated in a smoking cessation intervention program. Thirteen subjects ceased smoking (quitters), while 14 continued to smoke (cigarette smokers). NK activity before the intervention was correlated positively with age. NK activity remained almost constant among quitters, comparing the activity before and after the intervention, while it decreased among cigarette smokers although it was not statistically significant. In the subgroup analysis, NK activity increased among those aged less than 65 years, or urine cotinine levels over 800ng/ml before the intervention, especially among quitters. This suggests that smoking cessation intervention programs might have been more effective for younger than elder subjects in consideration of NK activity.[29]

Effect of smoking cessation on the peripheral neutrophil mRNA expression levels for inflammatory cytokines, chemokine, growth factor and matrix metalloproteinase (MMP) were assessed. The status of smoking and smoking cessation was verified by exhaled carbon monoxide (CO) concentration and serum cotinine concentration. Neutrophils were isolated from each subjects' peripheral blood, then the cell was stimulated with N-formylmethionyl-leucyl-phenylalanine (FMLP). The mRNA expression levels for interleukin (IL)-1b, IL-8, tumor necrosis factor (TNF)-a, vascular endothelial growth factor (VEGF) and MMP-8 were analyzed by semiquantitative reverse transcriptionpolymerase chain reactions. The same experiment was performed on 11 non-smoking controls. The inference of the study conveyed eleven of 16 smokers successfully completed smoking cessation for 8 weeks. At one day after smoking cessation, there was a statistically significantly lower CO concentration than at baseline. Also, cotinine concentration markedly decreased at the second measurement, which was taken at one week. The MMP-8 mRNA levels were significantly increased at 8 weeks after smoking cessation compared with the baseline. Hence the study states that the neutrophil transcript levels in smokers were generally lower than those in non-smokers, which could be related to an impairment of neutrophils by smoking effects. The significant increase of MMP-8 mRNA levels were associated with the effects of smoking cessation, while recovery of the other mRNA levels seemed to require a bit longer period beyond 8 weeks after smoking cessation.[30]

EFFECT OF SMOKING CESSATION ON BONE LOSS

Tobacco produces a greater loss of alveolar bone height in smokers than in nonsmokers, even when the former maintain a good level of hygiene.[31] This suggests that tobacco itself can directly produce periodontal bone loss, regardless of bacterial plaque levels, which are known to be the main etiological factors in the onset of periodontitis. The exact mechanisms by which tobacco exerts its influence on periodontal

breakdown are not completely known. It is likely that smoking primarily has a systemic influence by altering the host response and/or by directly damaging the periodontal cells.[32]

Jansson L et al evaluated the influence of smoking on longitudinal marginal bone loss and tooth loss in a prospective study over 20years. In addition, the effect of cessation of smoking on bone loss and the interaction between smoking, plaque and marginal bone loss were evaluated. A total of 507 dentate individuals from an epidemiological study were examined in 1970 and 1990. The clinical investigation included registration of number of remaining teeth and presence of plaque. The marginal bone level was determined by assessments on the proximal surfaces on the radiographs from 1970 and 1990. The marginal bone loss was defined as the difference in marginal bone level over 20years. The results conveyed that in 1970, 50.7% of the subjects were smokers, while the corresponding relative frequency in 1990 had decreased to 31.0%. Smoking was significantly correlated to an increased marginal bone loss over 20years. Individuals who stopped smoking between 1970 and 1990 lost significantly less marginal bone during this period than those who declared that they smoked during the 20-year period.[33]

INFLUENCE OF SMOKING CESSATION ON WOUND HEALING

Smoking is a recognized risk factor for healing complications after surgery, but the pathophysiological mechanisms remain largely unknown. The direct cutaneous vasoconstrictive action of nicotine, the increased levels of fibrinogen, hemoglobin and blood viscosity, excessive levels of carboxyhemoglobin in blood, compromised polymorphonuclear neutrophil (PMN) leukocyte function, as well as increased platelet adhesiveness have all been hypothesized to be mechanisms by which smoking compromises wound healing.[34,35]

Sørensen LT studied the influence of smoking and nicotine on wound healing processes and to establish if smoking cessation and nicotine replacement therapy reverse the mechanisms involved. The study revealed smoking decreases tissue oxygenation and aerobe metabolism temporarily. The inflammatory healing response is attenuated by a reduced inflammatory cell chemotactic responsiveness, migratory function, and oxidative bactericidal mechanisms. In addition, the release of proteolytic enzymes and inhibitors is imbalanced. The proliferative response is impaired by a reduced fibroblast migration and proliferation in addition to a downregulated collagen synthesis and deposition. Smoking cessation restores tissue oxygenation and metabolism rapidly. Inflammatory cell response is reversed in part within 4 weeks, whereas the proliferative response remains impaired. Nicotine does not affect tissue microenvironment, but appears to impair inflammation and stimulate proliferation. Hence the study highlights smoking has a transient effect on the tissue microenvironment and a prolonged effect on inflammatory and reparative cell functions leading to delayed healing and complications. Smoking cessation restores the tissue microenvironment rapidly and the inflammatory cellular functions within 4 weeks, but the proliferative response remain impaired. Nicotine and nicotine replacement drugs seem to attenuate inflammation and enhance proliferation but the effect appears to be marginal.[36]

Grossi S G et al. investigated the effect of cigarette smoking on 143 patients' clinical and microbiological responses to mechanical therapy. Treatment included four to six sessions of subgingival scaling and root planing and instruction in oral hygiene. Results indicate that current smokers have less healing and reduction in subgingival Bacteroides forsythus and Porphyromonas gingivalis after treatment compared to former and nonsmokers, suggesting that smoking impairs periodontal healing. As the healing and microbial response of former smokers is comparable to that of nonsmokers, smoking cessation may restore the normal periodontal healing response.[37]

In a systematic review conducted by T. Thomsen et al. conveyed patients scheduled to undergo surgery can benefit from intensive preoperative smoking cessation interventions lasting at least 4 weeks and including nicotine replacement therapy. Benefit accrues not only in terms of postoperative recovery but also in long-term health. This is in accord with current Cochrane Review evidence.[38]

Moller A M et al. investigated the effect of preoperative smoking intervention on the frequency of postoperative complications. The overall complication rate was 18% in the smoking intervention group and 52% in controls. The most significant effects of intervention were seen for wound-related complications (5% vs 31%), cardiovascular complications (0% vs 10%), and secondary surgery (4% vs 15%). Hence the inference gained from the study states that an effective smoking intervention programme 6-8 weeks before surgery reduces postoperative morbidity.[39]

INFLUENCE OF QUITTING SMOKING ON PERIODONTITIS

Although the detrimental effects of tobacco on the periodontal tissues have been reported extensively, little is known about the potential beneficial effect of smoking cessation on periodontal health. Tiago Fiorini conducted a systematic review to evaluate the effect of smoking cessation on periodontitis progression and response to periodontal therapy. One study reported that the progression of clinical attachment loss ≥3 mm during a 6-year period was approximately three times higher among smokers than quitters. Two studies (10 and 20 years of follow-up) observed a decrease in radiographic bone loss of ≈30% among quitters when com-

pared with smokers. Among individuals receiving non-surgical periodontal treatment, quitters were more likely to have periodontal probing depth reductions than non-quitters/ oscillators. No differences in clinical attachment loss were observed. Based on the limited available evidence, smoking cessation seems to have a positive influence on periodontitis occurrence and periodontal healing.[40]

The effects of smoking cessation on clinical and radiographic outcomes following non-surgical treatment in smokers with chronic periodontitis were longitudinally assessed. The study showed, after 12 months, of patients with complete data, 10 had continuously quit smoking (20% of the original population), 10 continued smoking and six were oscillators (those patients who quit and then relapsed). Analysis of probing depth reductions between baseline and month 12, however, and comparing quitters with the other two groups combined, demonstrated a significant difference in favor of quitters. Furthermore, quitters were significantly more likely to demonstrate probing depth reductions than non-quitters and oscillators. Hence the study signifies smoking cessation has an additional beneficial effect in reducing probing depths following non-surgical treatment over a 12-month period.[41]

Success rates in quitting smoking following smoking cessation advice given as part of a periodontal treatment compared very favorably to national quit rates achieved in specialist smoking cessation clinics. The dental profession has a crucial role to play in smoking cessation counselling, particularly for patients with chronic periodontitis.[42]

SMOKING CESSATION AND IMPLANT SUCCESS RATE

Smoking has a strong influence on the complication rates of implants resulting in significantly more marginal bone loss after implant placement. It also increases the incidence of peri-implantitis and adversely affects the success of bone grafts.[43]

A smoking cessation protocol was put in place by Crawford A Bain and he found through his study that there was a statistically significant difference in the failure rates between those who continued to smoke and those who were on the protocol. Because all failures occurred prior to prosthetic loading, they were not likely to be a result of prosthodontic overload or other external factors.[44]

CONCLUSION

Smoking can induce cytotoxic effect on human gingival fibroblasts, which results in a decrease in their capacity for adhesion and proliferation.[45] This could result in impaired maintenance, integrity and remodeling of oral connective tissue. Given the tenacity of smoking behavior, however, much work remains to be performed to determine the most effective and efficient cessation methods and a large scale, well designed epidemiologic and clinical studies are needed to explore the potential benefits and the challenges associated with smoking cessation programs in a dental setting.

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