Review Article

Detrimental Effects of Smoking on Periodontium in Health and Disease

Hansa Jain[1], **Sanjyot Mulay**[2]

[1]*B.D.S., Lecturer, Department of Pedodontics, Harsarn Dass Dental College, Ghaziabad, Uttar Pradesh, India,* [2]*M.D.S., Professor in the Department of Conservative Dentistry & Endodontics, Dr. D. Y. Patil Dental College & Hospital, Pune, Maharashtra, India*

Corresponding Author: *Dr. Hansa Jain, Harsarn Dass Dental College, Ghaziabad. Mobile: 8446407240. E-mail: drhansaliljain@gmail.com*

Abstract

Cigarette smoking is a preeminent prospect for the cause of jillions of diseases. The cause of the development and progression of periodontitis has received pervasive attention, with significant progress over the past decade in clinical, microbiological, immunological, biochemical, and behavioural domains. The list of risk factors embodies smoking, diabetes, socio-economic status and behaviour and stress. This review covers ordered studies to examine the potential causal association between cigarette smoking and periodontitis. A number of epidemiologic studies have shown strong associations between smoking and the prevalence and severity of periodontitis, as well as bone loss. Whereas the periodontopathogens in smokers is of major concern, some data also suggests modification of the periodontitis micro-flora by smoking is mired in the development of periodontitis. Also there are data suggesting smoking effects on both acquired and innate responses in humans and animals. The prevalence and severity of periodontitis in former smokers is lesser as compared to current smokers, providing affirmation that smoking cessation is beneficial. Smoking markedly sways response to periodontal therapy. Statistical analysis of smokers has also connected smoking with a large proportion of periodontal cases and constitutes a major dental public health problem.

Keywords: Immune response, Microflora, Periodontitis, Periodontium, Smoking, Tobacco

INTRODUCTION

Periodontitis is an array of inflammatory diseases affecting the periodontium, i.e., tissues supporting and lining the radical portion of teeth.[1] It is a chronic inflammatory disease associated with gram-negative anaerobic bacteria present in the dental biofilm which leads to irrevocable impairment of periodontium.[2] Periodontitis results in a continuous release of bacterial and inflammatory cytokines into saliva and to a certain degree into blood.[3] These periodontal pathogens and inflammatory markers travel via saliva and blood from the affected tissues to distant sites thus affecting systemic health adversely.[4] Also it has been found in the women of pregnancy associated gingivitis,that periodontal therapy reduces the rate of preterm low birth weight.[5]

The concept concerning the etiology of active periodontal disease considers three factors: A susceptible host, the presence of pathogenic species, and the absence of so-called "beneficial bacteria".[6] The search for the pathogens of periodontal diseases has been underway for more than 100 years, and till date it is a motif of concern. In addition, varied risk factors have been pinpointed as potential risk factors for periodontitis including smoking, diabetes, socioeconomic status, behaviour and stress. Amongst these smoking is strongly implicated in the development of periodontal disease. There is accumulating evidence for a higher level of periodontal disease among smokers. Greater levels of clinical alveolar bone loss, tooth mobility, probing pocket depth and tooth loss have been proclaimed to be more austere in smokers than in non-smokers.[7]

Smoking and Gingivitis

Smoking and its clinical manifestations on periodontium is evident, but paradoxically, smokers show reduced clinical signs of inflammation in response to dental plaque than non-smokers, particularly the key diagnostic indices of gingival bleeding on probing and oedema. It has been suggested that this reflects an alterations of the caliber of the blood vessels perfusing the gingival tissues which can be attributed to the cotinine, a nicotin metabolic by-product, as it has a peripheral constrictive action on gingival vessels that reduces gingival clinical signs of bleeding, redness

and oedema.[8,9] In vitro studies have also advertised altered gingival crevicular fluid inflammatory cytokine profiles, immune cell function and altered proteolylic regulation in smokers. Lately Chang et al. have demonstrated altered Cox-2 mRNA expression in gingival fibroblasts in response to nicotine.[10]

Smoking & Periodontitis

The relationship between smoking and periodontal health was investigated as early as the middle of the nineteenth century. More recently a wealth of epidemiological, clinical and in vitro studies have emerged that have provided undeniable evidence that smoking adversely effects periodontal health and proposed mechanisms by which it may ensue.[11]

In 1999, Gelskey used methodology of Sir Bradford Hill's criteria for causation, as a framework to examine potential causal association between cigarette smoking and periodontitis. He stated that smoking meets most of the criteria for causation proposed by Hill (1965). This statement was based on the fulfilment of parameters between smoking and periodontal disease severity demonstrated by multiple cross-sectional as well as longitudinal studies. The parameters were consistency, strength of association, specificity, temporality, biological gradient, biological plausibility/coherence, analogy and experiment.[12]

Studies have indicated that smokers exhibit increased bleeding upon probing, higher calculus and plaque deposits, increased clinical attachment loss, gingival recession and tooth mobility which was independent of age, gender and systemic condition.[13] The results of a study reported that the relative risk of between 2.66 and 4.55 for light and heavy smokers respectively. A report from Calsina et al claimedthat there is a 2.7 times greater probability to have established periodontitis in a study of Spanish adults over 20 years old. These investigators also perceived a more significant effect in male patients and reported that the probability of having disease increased to 3.7 in those who had been smoking for 10 years or more. Linden and Mullally, although reported low prevalence but found that when furcation defects exclusively affected smokers. In a subsequent radiographic investigation of an older adult population of referrals to a specialist periodontal clinic it was reported that the prevalence of molar furcation defects among cigarette smokers were twice of the matched group of non-smokers.[14,15]

Schenkein et al. reported on the clinical status of subjects with varying degrees of periodontal destruction. They found a higher prevalence of smoking among patients diagnosed with generalized early-onset or aggressive periodontitis and adult periodontitis than in those with localized juvenile periodontitis or with good periodontal health. They reported 20% of subjects with localised aggressive periodontitis, 43% with generalised and 16% of healthy subjects were smokers. Significant effects were also seen in relation with periodontal attachment loss in smokers and generalized early-onset periodontitis. These patients had significantly more extensive periodontitis, more teeth with affected sites, and a greater mean loss of attachment than patients who did not smoke. Several authors have also reported high prevalence of smoking amid patients with aggressive periodontitis.[16]

Later Bergstrom and Baljoon in Saudi Arabia published report on water pipe smoking and its relation to periodontal health. They substantially compared the effects of cigarette smoking and water pipe smoking in periodontal vertical bone loss measured by full sets of radiographs. The impact of water pipe smoking (that had sharp rise in consumption due to its popularity in the recent years in men and women of Middle East countries) is of the same magnitude as that of cigarette smoking.[17] Krall et al.concluded that men who smoke cigars or pipes were at increased risk of experiencing tooth loss. Cigar smokers also were at increased risk of tolerating alveolar bone loss. These elevations in risk were similar in magnitude to those observed in cigarette smokers.[18]

Further talking about the region affected most, a number of other clinical investigations have revealed that cigarette smokers with aggressive or early onset periodontitis have more extensive periodontal destruction in the maxillary region. In a Brazillian study it was shown that group of smokers laid out that higher alveolar bone resorption as compared to non-smokers, especially in the incisors region, and confirmed that cigarette consumption affects maxillary region more as compared to the lower jaw and basically the anterior area.[19]

Smoking and Oral Microflora

Mechanisms by which smoking affects the development of periodontitis are notioned to be both direct and indirect. It has been suggested that modification of the periodontal microflora by smoking is involved in the development of periodontitis. It was shown that in vitro exposure of bacteria to cigarette smoking resulted in a marked decrease in the numbers of viable bacteria.[20] In a study on 798 subjects with different smoking histories, Zambon et al reported that smokers had significantly higher levels of, and were at greater risk of infection by B. forsythia. Furthermore, they showed that smokers were 2.3 times more likely to harbour this periodontal pathogen than former smokers or non-smokers.[21] Umeda et al. reported that current smokers displayed an increased risk (odds ratio,

4.6) for harbouring T. denticola in periodontal pockets, and that the presence of A. actinomycetemcomitans, P. gingivalis, P. intermedia, E. corrodens or F. nucleatum. Also, smoking increased the risk of having a mean pocket depth of ≥3.5 mm.[22]

From few other in vitro studies, it has been reported that bacteria are eclectically affected by cigarette smoke and that smokers present a decreased oxygen tension in periodontal pockets, which could favour anaerobic colonization. In contrast, clinical studies have shown minor differences between smokers and nonsmokers with respect to periodontal microflora.[23] Haffajee and Socransky investigated the relationship between cigarette smoking and subgingival microbiota using checkerboard DNA hybridization. They concluded that the major difference between smokers and non-smokers was in the prevalence of species i.e. periodontal pathogens colonized a larger proportion of sites, rather than counts or proportions. The increased colonization seen among smokers was particularly evident at the shallower pockets, i.e. those, less than 4 mm. In addition they reported that a higher percentage of sites were colonized by B. forsythus and P. nigrescens in maxillary than mandibular sites.[24]

Smoking and Systemic Manifestations

Smoking of tobacco leads to a number of systemic manifestations including diabetes, pulmonary destruction, renal pathologies and osteoporosis. Literature suggests that smokers are insulin resistant, they exhibit several aspects of the insulin resistance syndrome and they are at an increased risk for type 2 diabetes. Smoking even increases risk for diabetic nephropathy, retinopathy, neuropathy, macrovascular complications, and peripheral vascular disease. Nicotine, one of the components of tobacco has a direct effect on the beta cells of the pancreas and smoking has also been associated with larger upper body fat distribution which is a marker of insulin resistance, raised plasma glucose concentration and overt diabetes.[25-27]

Studies have suggested that smoking is the most widespread pulmonary inflammation and its cessation is probably the single most exigent preventive manoeuvre one can offer. In a spirometric test Neri et al chronic obstructive pulmonary disease (COPD) was observed to be affected five folds or greater in smoker irrespective of age and gender than in non-smokers. Hyman and Ried carried out a survey to analyse the relationship between smoking and its effect on the relationship between COPD and periodontal inflammation. The results suggested that it is a co-factor in the association of these two diseases and the extent of pathological involvement depended on the amount of tobacco smoke patient was exposed to.[28,29]

Studies have also included renal diseases as a consequence of tobacco smoking. Chapman et al observed that patients suffering from proteinuria had a heavier smoking history than the patients without proteinuria. Ward et al stated that smoking at the time of onset of nephritis is an independent risk factor for accelerated progression to end stage renal disease. It has been observed that smoking causes damage to endothelial cells, interfere with the coagulation/fibrinolysis systems and regeneration of oxygen radicals, these factors might be the cause of the nexus between the two.[30,31]

Another pathology that might associate smoking and its side-effects on periodontium is osteoporosis, myriad of studies have documented that smoking increases incidence of bone fractures. It has been associated with a variety of metabolic effects, several of which suggest plausible mechanisms for smoking-related changes in bone density, including altered level of calcitonin, androstenedione and serum steroid hormone. Cessation or reduction in smoking has been considered an important factor for primary and secondary prevention of osteoporosis and good prognosis following treatment.[32,33]

All the mentioned systemic diseases have been observed to either exaggerate or cause periodontitis. Like diabetics have been observed to have intensified response to bacterial attack by periodontopathic microorganism thus causing periodontal destruction. The association has been suggested to be through activated monocyte response observed in type 2 diabetes.[34] Pulmonary dysfunction is the other disease included in the list. Higher prevalence of periodontitis has been observed in COPD. A study have indicated that COPD increased prevalence of periodontitis up to six fold when measured to control group and up to threefold when compared to random Scandinavian population. A study even concluded that improved oral hygiene and frequent professional oral health care reduces the progression and even occurrence of respiratory diseases among high risk patients.[35,36]

End stage renal disease has been to observe to cause increased gingival inflammation and increased plaque and calculus formation. Yoshikara et al ordained a study to analyse the impact of renal function and periodontal disease in Japanese elderly. The study concluded that there was a significant association between clinical attachment loss and renal impairment which was independent of gender, oral hygiene habits and previous dental profile.[37,38]

Smoking and Host Immunity

Bacteria causing periodontal breakdown release a number virulence factors thus resulting in activation of host response. The release of these virulence factors in

the body causes tissue destruction.[39] Further smoking suppresses both the innate and immune host responses. Hemorrhagic response of the periodontal tissue has also been observed to decrease in smokers. Though studies state that smokers have increased number of neutrophils, the first line of defence against bacterial infection but smokers have decreased activity of neutrophils including chemotaxis, phagocytosis, adherence and its capacity to produce cytokines. Evidence even adumbrate that smoking influences lymphocyte count and production of antibody. It increases the level of CD3+ and CD4+ cells in a dose-dependent manner. Immunoglobulins particularly IgG2 which has been observed to be an important antibody against gram negative periodontal pathogens and these have been shown to be dwindled in smokers when compared to non-smokers.[40] Tobacco smoke exposure to unstimulated neutrophils elevates the oxidative burst causing tissue destruction by a direct toxic effect.[41] Smoking also affects a number of biomarkers which have observed to affect periodontal tissues, for example smokers have reduced levels of prostaglandin (PG) E2, lactoferrin, albumin, aspartate aminotransferase, lactate dehydrogenase and alkaline phosphatise.[39]

Smoking has a detrimental effect on cytokines as well, as it significantly reduces concentration of interleukin (IL)-1, IL-1β and IL-1ra in gingival crevicular fluid. Serum IL-1β in patients with untreated aggressive periodontitis showed a positive correlation with smoking. Smokers have lower amounts of IL-4 in GCF in patients suffering from early onset periodontitis and even in patients with healthy periodontium. The amounts of IL-10 in GCF has been observed to be low in smokers than in non-smokers whereas levels of IL-6 and IL-8 increase with smoking.[42,43] Cigarette smoke exposure may lead to decreased release of IL-6, decrease in production and release of IL-1 and increase in tumor necrosis factor-α (TNF-α) levels when compared between smokers and non-smokers.[41,44] IL-1, IL-6 and TNF-α cause stimulation of the expression of the receptor activator of nuclear factor-κβ ligand (RANKL) and inhibitor protein osteoprotegerin (OPG). These two are essential for bone resorption and remodelling. It has been observed that smoking leads to reduction in OPG concentration even disturbing the RANKL/OPG ratio; smokers have increased RANKL/OPG ratio. As earlier observed level of PGE 2 and alkaline phosphatase is also affected by smoking, this might also be reason for increased periodontal bone destruction.[45]

Smoking and Periodontal Therapy

Tobacco use has a major influence on periodontal therapy. A reduction in clinical benefits in smokers following non-surgical periodontal therapy has been a consistent finding across many studies. The suggested mechanisms for this finding include inflammatory, immunological, microbiological and wound-healing phenomena.

Preber and Bergstrom reported that smokers did not respond as much as non-smokers to non-surgical therapy.[46] Ah et al. and Kaldahl et al., who reported less probing depth reduction and attachment gain in smokers who had been treated by periodontal surgery, corroborated this finding that smokers were poor candidates for successful periodontal care.[47] Kamma and Baehni reported that smoking was found to have significant predictive value of future attachment loss in a five-year follow up of 25 young adults diagnosed with early-onset periodontitis who had been receiving regular periodontal maintenance care.[48] Mc Guire and Nunn found twice the risk of tooth loss in smokers undergoing maintenance periodontal care over a five-year period.[49]

It also been noted that the effect of smoking on implant survival appeared to be more pronounced in areas of loose trabecular bone. Type II diabetes mellitus may have an adverse effect on implant survival rates which again as mentioned above is linked to both smoking and periodontal destruction. A history of treated periodontitis does not appear to adversely affect implant survival rates but it may have a negative influence on implant success rates, particularly over longer periods.[50]

Few studies have been carried out to find the use of alternative therapies in smokers, for example, in one of the novel therapeutic approach, there was enhanced connective tissue breakdown which was due to inhibition of metalloproteinase activity as demonstrated for tetracyclines.[51] Well-evaluated markers of collagen turnover, such as the pyridinoline cross-linked carboxyterminal telopeptide of type I collagen (ICTP), have been used to investigate alterations in bone breakdown and bone turnover. ICTP was reduced in patients with periodontitis following administration of low-dose doxycycline and with no effect on non-treated subjects.[52]

Smoking Cessation and Periodontitis

Literature suggests smoking is linked to tooth loss, but there is little information on the effect of smoking cessation on tooth loss risk.

Analysis of Veterans Administration Dental Longitudinal Study (DLS) participants found that the rate of tooth loss among men who quit smoking was about 50% lower than the rate among current smokers but still significantly higher than the rate among non-smokers.[53] However, that analysis did not address how risk might change with increasing length of abstinence. In a 12-year follow-up study of 1031 Swedish women, prospective rates of tooth

loss were similar in never smokers and former smokers who had abstained from smoking an average of 10 years before entering the study.[54] These findings are consistent with the arrested progression of periodontal bone loss and attachment loss observed when individuals quit smoking.[55]

The results of few studies suggest that tooth loss risk does decline after smoking cessation but the risk remains elevated in relation to non-smokers for at least 9-10 years. The reason is the loss of alveolar bone which is not reversible, so one might expect the cumulative damage to the bone tissue by cigarettes to be permanent. Removing exposure to smoke reduces the likelihood that disease will become widespread and affect more number of teeth. It is assumed that as time elapses, these other risk factors become more important and begins to obscure the differences due to smoking history. Finally, there are other lifestyle changes which may occur when an individual decides to quit smoking and may become more established as the duration of abstinence increases. Smokers who quit appear to be more health conscious than those who continue to smoke, and they make physician visits and use health screening programs at rates comparable to those of non-smokers.[56]

CONCLUSION

It can be concluded from the literature written above that smoking is the most important risk factor. It increases the risk of periodontitis irrespective of the genotype. This risk is further aggravated in subjects bearing particular alleles of the polymorphically expressed genes studied. While the precise mechanisms whereby cigarette smoking can exert an effect on periodontal tissues are not completely understood, it is clear that it is still the most significant preventable risk factor for periodontitis. Its effects are related to the duration and number of cigarettes consumed.

ACKNOWLEDGEMENT

The authors would like to thank Mrs. Parul Jain.

REFERENCES

1. Page RC, Schroeder HE. Pathogenesis of inflammatory periodontal disease. A summary of current work. *Lab Invest*. 1976 Mar;34(3):235-49.
2. Burt B, Research, Science and Therapy Committee of the American Academy of Periodontology. Position paper: epidemiology of periodontal diseases. *J Periodontol*. 2005 Aug;76(8):1406-19.
3. Champagne CME, Buchanan W, Reddy MS, Preisser JS, Beck JD, Offbencher S. Potential for gingival crevice fluid measures as predictors of risk for periodontal disease. *Periodontol 2000*. 2003;31:167-80.
4. Scannapieco FA, Wang B, Shiau HJ. Oral bacteria and respiratory infection: effects on respiratory pathogen adhesion and epithelial cell proinflammatory cytokine production. *Ann Periodontol*. 2001 Dec;6(1):78-86.
5. Lopez NJ, Da Silva I, Ipinza J, Gutierrez J. Periodontal therapy reduces the rate of preterm low birth weight in women with pregnancy-associated gingivitis. *J Periodontol*. 2005 Nov;76(11 Suppl):2144-53.
6. Socransky SS, Haffajee AD. The bacterial etiology of destructive periodontal disease: Current concepts. *J Periodontol*. 1992 Apr;63(4 Suppl):322-31.
7. Kubota M, Tanno-Nakanishi M, Yamada S, Okuda K, Ishihara K. Effect of smoking on subgingival microflora of patients with periodontitis in Japan. *BMC Oral Health*. 2011 Jan;11:1.
8. Bagaitkar J, Demuth DR, Daep CA, Renaud DE, Deanne L. Pierce DL. Tobacco Upregulates P. gingivalis Fimbrial Proteins Which Induce TLR2 Hyposensitivity. *PLoS One*. 2010 May;5(5):e9323.
9. Lima FR, Cesar-NetoJB, Lima DR, KerbauyWD, Nogueira-Filho GR. Smoking enhances bone loss in anterior teeth in a Brazilian population: A retrospective cross-sectional study. *Braz Oral Res*. 2008 Oct-Dec;22(4):328-33.
10. Van Dyke TE, Dave S. Risk factors for periodontitis. *J Int Acad Periodontol*. 2005 Jan;7(1):3-7.
11. Albandar JM, Streckfus CF, Adesanya MR, Winn DM. Cigar, pipe, and cigarette smoking as risk factors for periodontal disease and tooth loss. *J Periodontol*. 2000 Dec;71(12):1874-81.
12. Gelskey SC. Cigarette smoking and periodontitis: methodology to assess the strength of evidence in support of a causal association. *Community Dent Oral Epidemiol*. 1999 Feb;27(1):16-24.
13. Mahuca G, Rosales I, Lacalle JR, Mahuca C, Bullon P. Effect of cigarette smoking on periodontal status of healthy young adults. *J Periodontol*. 2000 Jan;71(1):73-8.
14. Linden GJ, Mullally BH. Cigarette smoking and periodontal destruction in young adults. *J Periodontol*. 1994 Jul;65(7):718-23.
15. Bergstrom J, Eliasson S. Cigarette smoking and alveolar bone height in subjects with a high standard of oral hygiene. *J Clin Periodontol*. 1987 Sep;14(8):466-9.
16. Mullally BH. The Influence of Tobacco Smoking on the Onset of Periodontitis in Young Persons. *Tob Induc Dis*. 2004 Jun 15;2(2):53-65.
17. Villar CC,Lima AFM. Smoking influences on the thickness of marginal gingival epithelium. *Pesqui Odontol Bras*. 2003 Jan-Mar;17(1):41-5.
18. Krall EA, Garvey AJ, Garcia RI. Alveolar Bone Loss And Tooth Loss In Male Cigar And Pipe Smokers. *J Am Dent Assoc*. 1999 Jan;130(1):57-64.
19. LimaFR, Cesar-Neto JB, Lima DR, Kerbauy WD, Nogueira-Filho GR. Smoking enhances bone loss in anterior teeth in a Brazilian population: a retrospective cross-sectional study. *Braz Oral Res*. 2008 Oct-Dec;22(4):328-33.
20. Bardell D. Viability of six species of normal oropharyngeal bacteria after exposure to cigarette smoke in vitro. *Microbios*. 1981;32(127):7-13.
21. Zambon JJ, Grossi SG, Machtei EE, Ho AW, Dunford R, Genco RJ. Cigarette smoking increases the risk for subgingival infection with periodontal pathogens. *J Periodontol*. 1996 Oct;67(10 Suppl):1050-4.
22. Umeda M, Chen C, Bakker I, Contreras A, Morrison JL, Slots J. Risk indicators for harboring periodontal pathogens. *J Periodontol*. 1998 Oct;69(10):1111-8.
23. Darby IB, Hodge PJ, Riggio MP, Kinane DF. Microbial comparison of smoker and non-smoker adult and early-onset periodontitis patients by polymerase chain reaction. *J Clin Periodontol*. 2000 Jun;27(6):417-24.
24. Haffajee AD, Socransky SS. Relationship of cigarette smoking to the subgingival microbiota. *J Clin Periodontol*. 2001 May;28(5):377-88.
25. Eliasson B. Cigarette smoking and diabetes. *Prog Cardiovasc Dis*. 2003 Mar-Apr;45(5):405-13.
26. Haire-Joshu D, Glasgow RE, Tibbs TL; American Diabetes Association. Smoking and diabetes. *Diabetes Care*. 2004 Jan;27 Suppl 1:S74-5.
27. Willi C, Bodenmann P, Ghali WA, Faris PD, Cornuz J. Active smoking and the risk of type 2 diabetes: a systematic review and meta-analysis. *JAMA*. 2007 Dec 12;298(22):2654-64.
28. Neri LC, Mandel JS, Hewitt D, Jurkowski D. Chronic obstructive pulmonary disease in two cities of contrasting air quality. *Can Med Assoc J*. 1975 Dec;113(11-12):1043-6.
29. Hyman JJ, Reid BC. Cigarette smoking, periodontal disease: and chronic obstructive pulmonary disease. *J Periodontol*. 2004 Jan;75(1):9-15.
30. Orth SR, Stockmann A, Conradt C, Ritz E, Ferro M, Kreusser W et al.Smoking as a risk factor for end-stage renal failure in men with primary renal disease. *Kidney Int*. 1998 Sep;54(3):926-31.
31. Ritz E, Benck U, Franek E, Keller C, Seyfarth M, Clorius J. Effects of smoking on renal hemodynamics in healthy volunteers and in patients with glomerular disease. *J Am Soc Nephrol*. 1998 Oct;9(10):1798-804.

32. Ill PO, Alexandre C. Tobacco as risk factor of osteoporosis, myth or reality? *Rev Rhum Ed Fr*. 1993 Apr;60(4):280-6.
33. Hollenbach KA, Barrett-Connor E, Edelstein SL, Holbrook T. Cigarette smoking and bone mineral density in older men and women. *Am J Public Health*. 1993 Sep;83(9):1265-70.
34. Taylor GW, Burt BA, Becker MP, Genco RJ, Shlossman M, Knowler WC et al. Non-insulin dependent diabetes mellitus and alveolar bone progression over 2 years. *J Periodontol*. 1998 Jan;69(1):76-83.
35. Leuckfeld I, Obregon-Whittle MV, Lund MB, Geiran O, Bjortuft O, Olsen I. Severe chronic obstructive pulmonary disease: Association with marginal bone loss in periodontitis. *Respir Med*. 2008 Apr;102(4):488-94.
36. Azarpazhooh A, Leake JL. Systematic review of the association between respiratory diseases and oral health. *J Periodontol*. 2006 Sep;77(9):1465-82.
37. Thorman R, Neovius M, Hylander B. Clinical findings in oral health during progression of chronic kidney disease to end-stage renal disease in a Swedish population. *Scand J Urol Nephrol*. 2009;43(2):154-9.
38. Yoshihara A, Deguchi T, Hanada N, Miyazaki H. Renal function and periodontal disease in elderly Japanese. *J Periodontol*. 2007 Jul;78(7):1241-8.
39. Zhang L, Henson BS, Camargo PM, Wong DT. The clinical value of salivary biomarkers for periodontal disease. *Periodontol 2000*. 2009;51:25-37.
40. Petropoulos G, McKay IJ, Hughes FJ. The association between neutrophil numbers and interleukin-1alpha concentrations in gingival crevicular fluid of smokers and non-smokers with periodontal disease. *J Clin Periodontol*. 2004 May;31(5):390-5.
41. Shirodaria S, Smith J, McKay IJ, Kennett CN, Hughes FJ. Polymorphisms in the IL-1A gene are correlated with levels of interleukin-1alpha protein in gingival crevicular fluid of teeth with severe periodontal disease. *J Dent Res*. 2000 Nov;79(11):1864-9.
42. Ojima M, Hanioka T. Destructive effects of smoking on molecular and genetic factors of periodontal disease. *Tob Induc Dis*. 2010 Feb 20;8:4
43. Jacob V, Vellappally S, Smejkalova J. The influence of cigarette smoking on various aspects of periodontal health. *Acta Medica (Hradec Kralove)*. 2007;50(1):3-5.
44. Kuschner WG, D'Alessandro A, Wong H, Blanc PD. Dose-dependent cigarette smoking-related inflammatory responses in healthy adults. *Eur Respir J*. 1996 Oct;9(10):1989-94.
45. Buduneli N, Biyikoglu B, Sherrabeh S, Lappin DF. Saliva concentrations of RANKL and osteoprotegerin in smoker versus non-smoker chronic periodontitis patients. *J Clin Periodontol*. 2008 Oct;35(10):846-52.
46. Preber H, Bergstrom J. The effect of non-surgical treatment on periodontal pockets in smokers and non-smokers. *J Clin Periodontol*. 1986 Apr;13(4):319-23.
47. Ah MKB, Johnson GK, Kaldahl KWB, Patil KD, Kalkwarf KL. The effect of smoking on the response to periodontal therapy. *J Clin Periodontol*. 1994 Feb;21(2):91-7.
48. Kaldahl WB, Johnson GK, Patil KD, Kalkwarf KL. Levels of cigarette consumption and response to periodontal therapy. *J Periodontol*. 1996 Jul;67(7):675-81.
49. Kamma JJ, Baehni PC. Five-year maintenance follow-up of early-onset periodontitis patients. *J Clin Periodontol*. 2003 Jun;30(6):562-72.
50. Klokkevold PR, Han TJ. How do smoking, diabetes, and periodontitis affect outcomes of implant treatment? *Int J Oral Maxillofac Implants*. 2007;22 Suppl:173-202.
51. Golub LM, Lee HM, Greenwald RA, Ryan ME, Sorsa T, Salo T et al. A matrix metalloproteinase inhibitor reduces bone-type collagen degradation fragments and specific collagenases in gingival crevicular fluid during adult periodontitis. *Inflamm Res*. 1997 Aug;46(8):310-9.
52. Sarment DP, Cooke JW, Miller SE, Jin Q, McGuire MK, Kao RT, et al. Effect of rhPDGF-BB on bone turnover during periodontal repair. *J Clin Periodontol*. 2006 Feb;33(2):135-40.
53. Krall EA, Dawson-Hughes B, Garvey AJ, Garcia RI. Smoking, smoking cessation, and tooth loss. *J Evid Based Dent Pract*. 2008 Jun;8(2):105-7.
54. Ahlqwist M, Bengtsson C, Hollender L, Lapidus L, Osterberg T. Smoking habits and tooth loss in Swedish women. *Community Dent Oral Epidemiol*. 1989 Jun;17(3):144-7.
55. Bergstrom J, Eliasson S, Dock J. A 10-year prospective study of tobacco smoking and periodontal health. *J Periodontol*. 2000 Aug;71(8):1338-47.
56. Rimer BK, Orleans CT, Keintz MK, Cristinzio S, Fleisher L. The older smoker: status, challenges and opportunities for intervention. *Chest*. 1990 Mar;97(3):547-53.

How to cite this article: Hansa Jain, Sanjyot Mulay. "Detrimental Effects of Smoking on Periodontium in Health and Disease". Int J Sci Stud. 2014;2(3):76-81.

Source of Support: Nil, **Conflict of Interest:** None declared.