Periodontal Diseases: A Covert Focus of Inflammation in Pulmonary Diseases

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Abstract

Pulmonary diseases have known to exert significant human sufferings with high death toll globally. The association between periodontitis and pulmonary diseases is still in its infancy and needs attention. Poor oral health has shown to influence pulmonary health as well as the course of the diseases associated with this system. Numerous studies have emphasized that resident microorganisms of lungs are primarily the habitants of oral cavity. It could be due to the aspiration of oral periodontopathic bacteria into the lungs, thereby initiating the inflammatory process. Added to this, the inflammatory mediators elaborated from the inflamed periodontium in case of periodontal diseases may spread via blood to other organs such as lungs causing infections. Numerous studies have highlighted the beneficial role of periodontal therapy in improving lung function with a decreased frequency of exacerbations, reduced risk of adverse respiratory events, and morbidity, especially in chronic obstructive pulmonary disease patients. Medically compromised dentate patients admitted in intensive care units owing to their inability to maintain oral hygiene properly have increased propensity of acquiring respiratory infections. The present review focuses on emphasizing the relationship between periodontitis and pulmonary diseases with the available published literature utilizing PubMed and Google Scholar databases in the last four decades.

Keywords: Aspiration pneumonia, asthma, bronchiectasis, chronic obstructive pulmonary diseases, chronic periodontitis, tuberculosis

INTRODUCTION

A growing interest has emerged relative to the relationship between oral health and systemic diseases since the last few decades.^[1,2] Compelling evidence has highlighted the pivotal link between oral health and respiratory health due to the anatomical communication between the two. Pulmonary diseases have led to disability with high mortality rate and economic burden on the sufferers. It was estimated that the total mortality because of the lower respiratory infections remained roughly constant from 2005 to 2015, i.e., between 2.7 million and 2.8 million deaths.^[3] Chronic respiratory diseases constitute around 4% of the global burden with overall burden of chronic diseases as 8.3%. Recent accumulating evidence is suggestive of a high prevalence of allergic disorders, asthma, and chronic obstructive pulmonary disease (COPD) in the Asia-Pacific region.^[4-7] There are limited data on the respiratory disease burden in India, with recent reports showing prevalence ranging from 2.05% to 3.5%.^[8,9]

The prime sufferers of community-acquired pneumonia are the ones that are affected by seizures, cerebral stroke, alcohol

abuse, etc. These conditions affect their cognitive ability, thereby increasing the chances of aspirating oropharyngeal secretions and hence respiratory infections. Smoking leads to compromised mucociliary barrier and phagocytic cell activity. Other predisposing factors causing immunological and physiological compromise include congenital derangements in immune-defense, acquired immunodeficiency, COPD, and hospitalized patients. It also leads to emergence of antibiotic-resistant pathogens in such patients and ultimately more susceptibility to pulmonary infections.

PATIENTS AND METHODS

The present review discusses the studies utilizing the electronic databases PubMed and Google Scholar from 1977 to 2017

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using keywords “Aspiration pneumonia,” “Asthma,” “Chronic obstructive pulmonary diseases,” “Chronic periodontitis,” “Tuberculosis,” and “Bronchiectasis” utilizing the Boolean operators “AND,” “OR,” and “NOT” in various combinations. The authors have utilized the five most common pulmonary diseases that are found to be associated with periodontal diseases on the basis of the published literature. A total of 76 scientific papers (33 observational studies, 16 interventional studies including 6 randomized controlled trials, 11 review articles including 1 systematic review and meta-analysis, and 16 *in vitro* studies) and 3 book reviews meeting the criteria were scrutinized for reviewing.

DENTAL PLAQUE: THE REPOSITORY OF PULMONARY PATHOGENS

Incredible increase in the quantity as well as complexity of dental biofilm was observed in hospitalized and critically ill patients because of their inadequate oral hygiene maintenance.^[10-13] The interaction between the resident dental plaque flora and established respiratory microbes^[14] ultimately leads to colonization by the latter in the niches of oral cavity. Consequently, dental plaque may shed into the salivary fluids due to a number of physiological forces contaminating the respiratory tree distally on aspiration [Figure 1].

The mechanisms explaining the prime role of periodontal bacteria in the etiopathogenesis of pulmonary infections have been proposed in the existing published literature. These are as follows: (1) aspiration of oral pathogens and specially of periodontal interest are *Porphyromonas gingivalis*, *Actinobacillus actinomycetemcomitans*,

etc.^[15-23] [Figure 2], (2) modification of mucosal surface by periodontitis-associated salivary enzymes promoting adhesion and colonization by pulmonary pathogens^[24-29] [Figure 3], (3) enzymatic disintegration of salivary pellicle adsorbed on pathogenic bacteria^[30,31] [Figure 4], and (4) alteration of pulmonary epithelium by the cytokines that are elaborated in periodontitis promoting enhanced infection by respiratory pathogens^[32-35] [Figure 5].

INTERRELATION BETWEEN BACTERIAL PNEUMONIA AND PERIODONTAL DISEASE

Bacterial pneumonia, in brief, is a parenchymal infection of lungs caused by a wide spectrum of microorganisms, i.e., bacteria, parasites, viruses, and fungi. It can develop either as *de novo* or as a superimposed infection due to a primary viral infection. Broadly categorized as hospital acquired (nosocomial) and community acquired, these differ relative to the spectrum of etiological agents. Epidemiological studies on ten Asian countries including India have reported that hospital-acquired pneumonia (HAP) accounts for an incidence rate of 1–21 cases in every 1000 patients who are admitted to hospital.^[36] HAP is associated with a high morbidity and mortality with long patient stay and economic burden on the patient. Ventilated patients in intensive care units with more than 48 h of ventilation are at continual risk for acquiring ventilator-assisted pneumonia (VAP) because of their incapability for oropharyngeal secretion clearance.

The etiopathogenesis involved in adult bacterial pneumonia is through aspiration of oropharyngeal secretions loaded with pathogens into the lower respiratory tree. This leads to

Figure 1: Link between periodontal bacteria and pulmonary infections. Due to the movement of the muscles of tongue and cheek during speech and mastication and by the flow of saliva, the dental plaque gets dislodged into saliva. It contains pathogenic bacteria associated with both periodontitis (*Porphyromonas gingivalis*, *Actinobacillus actinomycetemcomitans*, etc.) and pulmonary diseases (*Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, etc.). Salivary fluid containing inflammatory cytokines that seeps along with gingival crevicular fluid may initiate and progress pulmonary infection by stimulating a local inflammatory process

Figure 2: Possible mechanism of pulmonary infection via aspiration route

Figure 3: Possible mechanism of alteration of oral mucosal surfaces by periodontitis associated enzymes (proteases, sialidase, fucosidase, etc.) resulting in adhesion and colonization pulmonary pathogens

collapse in host immune system responsible for eliminating the aspirated oral pathogens, which get a fair chance to multiply and flourish causing pulmonary infection. Since it is well established that pneumonia can be a resultant infection caused by anaerobic bacterial species, periodontitis patients carrying a large number of subgingival anaerobic bacteria can explain for a logical link between the two diseases. Perhaps infected lung fluids on culturing demonstrated various facultative and anaerobic microbial species of periodontal interest such as *P. gingivalis*, *Bacteroides* species, *Fusobacterium nucleatum*, and *A. actinomycetemcomitans*.^[37,38]

It is well accepted that bacteria associated with an infectious process evoke a strong immunogenic response systemically. Antibody response to *Prevotella* species has been studied in periodontitis human subjects. A prospective study has also

confirmed that patients suffering from VAP associated with *Prevotella* species elicit a strong systemic humoral response which seems to be specific to different species. Further, in the experimental group (patients who develop VAP associated with *Prevotella* species), the immunoglobulin M (IgM) titer was suggestive of a secondary immune response lacking IgM, indicating that the patients may have had a previous periodontal infections with these bacteria.^[23] Therefore, it can be interpreted that colonization by *Prevotella* species in periodontitis patients may evoke a humoral immune response with consequent VAP.

Hence, in the elderly population, a correlation exists between dentition status and aspiration pneumonia. Numerous recommendations have been proposed to reduce the incidence of aspiration pneumonia in the form of either topical chemotherapeutic decontamination or mechanical oral hygiene

Figure 4: Mechanism explaining destruction of salivary pellicle by periodontal bacteria

Figure 5: Mechanism explaining alteration of respiratory epithelium by salivary cytokines

maintenance by the professionals^[10,24,39-47] and are summarized in Table 1a.

THE LINKAGE BETWEEN CHRONIC OBSTRUCTIVE PULMONARY DISEASE AND CHRONIC PERIODONTITIS

COPD is an important global disease associated with quite a number of preventable risk factors. It is described as continuing obstruction to airflow that is progressive. It occurs as a result of exaggerated inflammatory response within airways and lungs that is chronic in nature. It is manifested in different variants such as emphysema, chronic bronchitis, and small airway disease.

Due to its heterogeneity and complexity, a set of standards has been defined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) in 1998 for accurate assessment and treatment of COPD. However, since COPD is not solely dependent on pulmonary function status but also dependent on the symptom burden and exacerbation frequency, the GOLD severity classification underwent a revision in 2011 to add assessment of symptom burden as well either by COPD assessment test^[48] or Modified British Medical Research Council scale^[49] with accompanying exacerbation history and

accordingly grading into Groups A-D. In a recent update in GOLD classification, 2017, the risk profiling grading of the patients into A-D was based totally on symptom burden and history of exacerbation. Further spirometry readings were used to grade the patients from 1 to 4 on the basis of airflow limitation.

The role of periodontal disease as a risk factor for COPD has received exponential interest of the researchers over the last two decades due to the possibility of aspirating periodontal pathogens since oral cavity and lungs harbor anatomical communication. Furthermore, acute exacerbations are prevalent in COPD patients, majority of which remain unreported and deteriorate quality of life. Microaspiration occurs in healthy situations, but the local defense (mechanical and immunological) mechanism provides protection to the distal airways and parenchyma of lungs. However, in pulmonary disease patients with poor oral hygiene and periodontitis, the bacteria-laden oral secretions may not be cleared off, resulting in respiratory airway colonization and inflammation.^[50] Another possibility could be an acute phase reaction systemically due to the elaboration of biological mediators into circulation from the periodontally inflamed tissue. Although many epidemiological studies

Table 1a: Aspiration pneumonia versus chronic periodontitis

Author	Type of study	Years	Conclusion
Scannapieco <i>et al.</i> ^[10]	Prospective Observational study	1992	In medical ICU patients, dental plaque and oral mucosa can be a potential reservoir of bacteria causing nosocomial pneumonia, and oral hygiene maintenance can reduce not only dental plaque load but also oropharyngeal colonization
Langmore <i>et al.</i> ^[24]	Prospective outcome study	1998	Predictive risk factor such as oral/dental status was identified as a contributor to the pathogenesis of aspiration pneumonia
Fourrier <i>et al.</i> ^[39]	Prospective Observational study	September 2000	Colonization of dental plaque by aerobic pathogens might be a source of nosocomial infection (pneumonia and bacteremia) in ICU patients
Genuit <i>et al.</i> ^[40]	Prospective study	2001	Improved oral hygiene via topical CHX application in conjunction with the use of a ventilator weaning protocol is effective in reducing the incidence of VAP and the duration of mechanical ventilation in surgical ICU patients
Adachi <i>et al.</i> ^[41]	Observational Study	August 2002	Professional oral health care in elderly patients requiring daily nursing care was related with reduced prevalence in fatal pneumonia
Koeman <i>et al.</i> ^[42]	Randomized, double-blind, placebo control trial	2006	Oral decontamination with topical CHX or CHX/COL reduces the incidence of VAP
Awano <i>et al.</i> ^[43]	Longitudinal study	April 2008	Mortality as a result of pneumonia was 3.9 times higher in persons with 10 or more teeth with a probing depth exceeding 4 mm than in those without periodontal pockets
Ishikawa <i>et al.</i> ^[44]	Interventional study	June 2008	In dependent elderly individuals, professional mechanical cleaning of the oral cavity on weekly basis, rather than a daily chemical oral disinfection, can prove to be an important strategic consideration to avoid aspiration pneumonia
Munro <i>et al.</i> ^[45]	Randomized controlled clinical trial	September 2009	CHX, but not toothbrushing, reduced early VAP in critically ill patients without pneumonia at baseline
Iinuma <i>et al.</i> ^[46]	Prospective observational study	March 2015	In edentulous denture wearing patients, there is increased risk for acquiring pneumonia, suggesting the role of denture-associated biofilm acting as a reservoir for pulmonary infection
Juthani-Mehta <i>et al.</i> ^[47]	Randomized controlled trial	March 2015	Institution of manual oral brushing plus 0.12% CHX oral rinse, twice daily, plus upright positioning during feeding, reduces the incidence pneumonia in nursing home elderly patients

VAP: Ventilator-assisted pneumonia, ICU: Intensive care unit, CHX: Chlorhexidine, COL: Colistin

have been conducted with positive results on association between periodontitis and risk of COPD,^[50-54,63-69] owing to the heterogeneity in utilization of measuring parameters and target population, the association showed variable results.

Briefly, both the diseases have similarity in the risk factors as well as the mechanisms behind their pathophysiology. Both are characterized by chronic inflammation with heavy infiltration by neutrophils and consequent loss of connective tissue due to proteolytic activity. This implicates that diagnosing and treating one disease properly would have a direct effect on the other diseases in terms of reduction in severity and/or disease progression. Studies highlighting the role of respiratory disease on oral health status along with the impact of periodontal attachment loss on the risk of occurrence of COPD and periodontal treatment in reducing exacerbations are summarized in Table 1b.

ASSOCIATION BETWEEN ASTHMA AND CHRONIC PERIODONTITIS

Asthma is a chronic disease of airways, which get narrowed down either temporarily or permanently bringing about breathing difficulty. Although it occurs in people of all ages, the peak prevalence is seen between 6 and 11 years. It is characterized by recurrent episodic attacks of coughing, wheezing, and dyspnea.

The prevalence of asthma has been reported with alarming rise throughout the world. The most important etiological agent for asthma is mainly a Type E antibody-mediated allergic hypersensitivity reaction. This is characterized by the recruitment of the mast cells with the resultant elaboration of chemical mediators such as histamine. A similar kind of cellular picture is noticed in cases of gingivitis that give direction toward a similarity at immunological level between allergic reactions and periodontal diseases.^[55] The risk factors in asthma include genetics, host-derived factors, and environmental factors.

Although the initial studies finding an association between periodontitis and asthma were conducted in the 1970s, they showed inconclusive results.^[57] Further, only a small number of studies till date have highlighted the link between periodontal diseases and asthma, including other similar kind of respiratory allergies.^[56-62,70-73] A casual association has been proposed between the two diseases. This could be due to either the aspiration of oropharyngeal secretions laden with periodontal pathogens or spread of biochemical mediators from the inflamed periodontium via blood to distant organs such as lungs. Thus, poor oral hygiene can lead to worsening of pulmonary functions with increase in a number of exacerbations of asthmatic attacks. Proper management of periodontitis can benefit such asthmatic patients.

Table 1b: Chronic obstructive pulmonary disease versus chronic periodontitis

Author	Type of study	Years	Conclusion
Scannapieco <i>et al.</i> ^[51]	Case-control study	July 1998	Significant associations between respiratory diseases (acute pneumonia, emphysema, and chronic bronchitis) and oral health in community-dwelling populations were seen
Hayes <i>et al.</i> ^[63]	Longitudinal observational study	July 1998	Increased radiographic alveolar bone loss was associated with an increased risk of COPD
Scannapieco and Ho ^[64]	Cross-sectional retrospective study	January 2001	COPD patients had more periodontal attachment loss than individuals without COPD. Individuals with mean periodontal attachment loss equal or more than 3 mm had a higher risk of COPD than with lower values
Hyman and Reid ^[65]	Observational study	2004	Smoking might act as a cofactor in the association between periodontal disease and chronic obstructive pulmonary disease
Kowalski <i>et al.</i> ^[66]	Observational study	October 2005	Increased frequency and intensification of periodontal disease in COPD was found
Katancik <i>et al.</i> ^[67]	Cross-sectional study	November 2005	Does not reveal any significant association between periodontal disease and airway obstruction, particularly in former smokers
Leuckfeld <i>et al.</i> ^[68]	Cross-sectional retrospective study	April 2008	Demonstrated that chronic marginal periodontitis to be common in patients with severe COPD and its high prevalence was found to be an independent possible risk factor
Deo <i>et al.</i> ^[69]	Retrospective study	October-December 2009	Severity in periodontal attachment loss was linked with increased risk of having COPD
Prasanna ^[50]	Observational study	October 2011	Association between periodontal disease and COPD with periodontitis as one of the risk factors
Si <i>et al.</i> ^[52]	Case-control study	2012	A strong association was found between periodontitis and COPD with plaque index to be a major predictor among Chinese adults
Kucukcoskun <i>et al.</i> ^[53]	Prospective, controlled group trial	July 2013	significant reduction was found in exacerbation frequency in COPD patients with chronic periodontitis who received periodontal therapy
Zhou <i>et al.</i> ^[54]	Pilot RCT	April 2014	Both scaling and root planing and supragingival scaling improved periodontal indices and lung function and reduced the frequency of chronic obstructive pulmonary disease exacerbations

COPD: Chronic obstructive pulmonary disease

Apart from the direct effect that periodontal diseases have on asthmatic patients, there is reciprocal association also, i.e., the inhalers bring about change not only in pH but also a consequent reduction in salivary formation. This results in more dental plaque formation, thereby increasing the severity of periodontal disease. Further, corticosteroids that are utilized in asthmatic patients are immunosuppressive and cause reduced host immune response with resultant decreased expression of periodontal disease clinically.

The literature available throws light on the possible link between asthma and periodontal disease [Table 1c]. Added to this, there are secondary factors such as medications affecting the association. Due to the paucity of studies, the need of the hour is more number of longitudinal studies with greater sample size. This would lead to a better assessment of the possible association between the two diseases, so that the mechanisms behind their etiopathogenesis can be explored well along with their treatment more efficiently.

RELATION BETWEEN TUBERCULOSIS AND CHRONIC PERIODONTITIS

Tuberculosis (TB) is considered to be one of the major debilitating diseases in most developing countries like India. It is a chronic granulomatous disease that primarily affects lungs although it can affect extrapulmonary sites such as skin,

bones, lymph nodes, kidney, and oral cavity. According to the WHO report (2017), TB is the ninth leading cause of mortality worldwide with India alone accounting for 33% of TB deaths globally among HIV-negative people and 26% of the altogether total TB deaths in HIV-negative and HIV-positive people.

The treatment of TB involving highly efficacious chemotherapeutic agents has led to the occurrence of <1% of tuberculous lesions in oral cavity. Primary lesions are rare, affecting younger adults with propensity toward gingival tissues. The cause of this rarity might be due to the presence of intact and thick squamous epithelium and protective role of saliva. On the contrary, secondary lesions affect older adults accounting for around 0.005%–1.5% of all cases.

Accumulating evidence has regarded TB as a predisposing or contributing factor in the pathogenesis of periodontal disease. Orofacial TB is not easy to diagnose and TB bacilli present in oral cavity may spread easily via saliva during expectoration. Since TB bacilli can survive in environment of low oxygen tension, periodontal pocket may act as a favorable site for colonization of this bacteria. There are numerous studies showing involvement of gingiva in systemic TB. A microbiological study utilizing the nested polymerase chain reaction in TB patients with periodontitis detected *Mycobacterium TB* in both plaque (92%) and saliva (68%) samples. This might be a possible risk of

Table 1c: Asthma versus chronic periodontitis

Author	Type of study	Years	Conclusion
Hyypä <i>et al.</i> ^[57]	Observational study	1979	Gingival inflammation gets increased in asthmatic patients
Laurikainen K, Kuusisto P ^[64,80]	Observational study (case-control)	March 1998	Periodontal status index in asthmatics was comparatively higher than nonasthmatic individuals
Shulman <i>et al.</i> ^[58]	Cross-sectional study	May 2003	No association was seen between asthma and periodontal health in an adolescent population
Friedrich <i>et al.</i> ^[59]	Observational study	April 2006	Slightly inverse association was found between asthma-like respiratory allergies and periodontitis
Yaghobee <i>et al.</i> ^[60]	Case-control study	2008	Periodontal indices (papillary bleeding index and gingival index) and attachment loss were higher among asthmatics
Gomes-Filho <i>et al.</i> ^[61]	Case-control study	June 2014	Higher frequency of periodontitis in individuals with severe asthma than in those without a diagnosis of bronchial inflammation
Rivera <i>et al.</i> ^[62]	Longitudinal study	July 2016	Stronger evidence of an inverse association was seen when using asthma medication as outcome in patients with severe periodontitis, i.e., less likely to have asthma
Lee <i>et al.</i> ^[70]	Cross-sectional study	June 2017	Positive association between periodontitis and current asthma condition. Individuals taking scheduled antiasthmatic medications are less likely to be diagnosed with periodontitis
Shen <i>et al.</i> ^[71]	Retrospective Cohort study	August 2017	Asthmatic patients are at elevated risk of developing periodontal diseases
Soledade-Marques <i>et al.</i> ^[72]	Case-control study	April 2018	Frequency of asthma in individuals with periodontitis had about a three-fold increased risk than that of those without asthma
Moraschini <i>et al.</i> ^[73]	Systematic review and meta-analysis	April 2018	Strongly suggests association of asthma with periodontal disease

transmitting the bacteria via aerosols during dental treatment. A clinicomorphological study in periodontitis patients with pulmonary TB demonstrated small-to-middle-sized periodontal foci of infection, suggesting immune or minor tuberculous inflammation with reparative processes.^[74]

Studies highlighting the impact of pulmonary TB on periodontium are incorporated in Table 1d.

PUTATIVE ASSOCIATION BETWEEN BRONCHIECTASIS AND CHRONIC PERIODONTITIS

Bronchiectasis (Bronchitis - airway; ectasia - dilatation) is described as abnormal, irreversible dilatation with thickened walls of bronchi. The abnormality seen in this disease primarily affects medium-sized bronchi, but can involve distal bronchi and bronchioles. It is clinically manifested with chronic cough and large amounts of mucopurulent expectoration. The possible etiology can be prior pulmonary infection, genetic predisposition with disorders affecting immunity, and idiopathic nature affecting up to approximately half of the individuals. According to an epidemiological survey analysis, 2012, there has been the highest prevalence of bronchiectasis cases that has been noticed in the Asia-Pacific countries.

Since both chronic periodontitis and bronchiectasis are chronic inflammatory diseases involving host-immune system, it might be possible that these diseases are linked as far as pathophysiology is concerned. Only two study protocols internationally have been proposed at present aiming at finding an association between the two diseases: one aiming at evaluating the improvement in pulmonary function, quality of life, and number of pulmonary exacerbations^[78] and other

assessing the microbial load in saliva, sputum, and nasal lavage after periodontal treatment.^[79] At national level, no such study is documented. Due to the paucity of literature, it can be hoped that since COPD that bears clinical similarity with bronchiectasis, there might be possible linkage between the two at the level of signaling mechanisms involved in inflammatory pathways [Table 1e].

CONCLUSION

Poor periodontal health in patients with pulmonary disease is of prime concern owing to the possibility of aspirating periodontal microbes into lungs and the presence of defective respiratory defensive system in these patients. This increases the chances of colonization and multiplication of periodontal pathogens in respiratory pathways and initiating a local inflammatory reaction by altering the quality of respiratory epithelium at that site. Furthermore, this alteration can be attributed to the presence of periodontitis-associated cytokines and hydrolytic enzymes present in oropharyngeal secretions. Further, the biological mediators released from the inflamed periodontal tissues might reach distant organs such as lungs and cause pulmonary inflammation. Other mechanisms attempting to explain the role of periodontal bacteria in causing respiratory diseases can be the destruction of salivary pellicle on pathogenic bacteria by periodontitis-associated enzymes preventing their clearance from the mucosal surfaces.

Thus, poor oral health makes the patients suffering from pulmonary diseases (such as pneumonia, COPD, TB, and bronchiectasis) more susceptible to exacerbations and disease progression, especially hospitalized patients. There is epidemiologic evidence, suggesting that improved periodontal

Table 1d: Tuberculosis versus chronic periodontitis

Author	Type of study	Years	Conclusion
Avdonina <i>et al.</i> ^[74]	Observational study	1993	Persistent L-forms of <i>M. tuberculosis</i> (59.3%) brought out a symptomless periodontitis with small- and middle-sized PFI, manifest immune or minor tuberculous inflammation, reparative processes. The findings suggest that PFI in tuberculous patients' periodontitis is a form of extrapulmonary TB
Anjum <i>et al.</i> ^[75]	Cross-sectional observational study	November 2010	No relationship between duration of illness and the periodontal status in TB patients
Palakuru <i>et al.</i> ^[76]	<i>In vitro</i> study	November-December 2012	TB status had no influence on the periodontal status. However, the presence of <i>M. tuberculosis</i> in saliva and dental plaque might pose a risk of transmission of disease through aerosols during dental procedures
Sharma <i>et al.</i> ^[77]	Case-control study	October 2016	Increased probing depth and bleeding on probing was found to be associated with TB patients than non-TB patients, concluding that periodontal status might be linked with TB

TB: Tuberculosis, *M. tuberculosis*: *Mycobacterium tuberculosis*, PFI: Periodal foci of infection

Table 1e: Bronchiectasis versus chronic periodontitis

Author	Type of study	Years	Conclusion
Pinto <i>et al.</i> ^[79]	Randomized controlled trial protocol	2016	Under progress
Santos SR <i>et al.</i> ^[78]	Randomized controlled trial protocol	2017	Under progress

health by proper dental management can reduce the number of pulmonary exacerbations and improve pulmonary functions and quality of life of patients. Further longitudinal studies with large sample size are needed to explore the putative association between periodontal disease and pulmonary diseases and to unravel the similar mechanisms involved in their pathogenesis not only at molecular level but also at genetic level. The novel genes should be identified which shows similar kind of differential expression in both these diseases that can be later on be targeted for diagnostic, prognostic, and therapeutic purposes.

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There are no conflicts of interest.

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