Review Article

Association between rheumatoid arthritis and periodontal disease: A meta-analysis

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Abstract

Rheumatoid arthritis (RA) is related to periodontal disease (PD) because both diseases share similar inflammatory pathogenic mechanisms that produce bone resorption. To assess the possible bidirectional link between RA and PD. A search for articles on RA and PD was conducted in the following electronic databases: PubMed (MEDLINE, Cochrane Library), Web of Science (WoS), and Google Scholar. Twenty-two studies with a low-moderate risk of bias according to the Newcastle-Ottawa Methodological Quality Scale were considered in this meta-analysis. The data were analyzed using the Statistical Software RevMan 5.4 (The Cochrane Collaboration, Oxford, UK). For continuous outcomes, the estimates of effects of the intervention were expressed as mean differences (MDs) using the inverse variance method, and for dichotomous outcomes, the estimates of effects of the intervention were expressed as odds ratios (OR) using the Mantel-Haenszel method, both with 95% confidence intervals. Patients with RA showed higher levels of: Plaque index (MD: 0.10; $P < 0.001$), gingival index (MD: 0.31; $P < 0.001$), probing depth (MD: 0.45; $P < 0.001$), clinical attachment loss (MD: 0.59; $P < 0.001$), and bleeding on probing (MD: 8.06; $P < 0.001$). They also had a lower number of remaining teeth (MD:-0.80; $P = 0.27$) and a greater number of missing teeth (MD: 2.70; $P < 0.001$). These same patients had a higher risk of both moderate (OR: 2.90; $P = 0.008$) and severe periodontitis (OR: 2.78; $P = 0.01$). Patients with RA have a higher risk of moderate-severe PD and a worsening of all periodontal parameters.

Keywords: Arthritis, case–control studies, periodontal diseases, rheumatic diseases, rheumatoid

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INTRODUCTION

Rheumatoid arthritis (RA) is an inflammatory disease, characterized by chronic synovial inflammation the ultimate destruction of cartilage and bone. RA could be associated with periodontal disease (PD) because both share similar inflammatory pathogenic mechanisms that produce bone resorption.[1] Although both conditions have different etiologies, RA (autoimmune) and PD (dysbiotic microbial biofilm), there are similar biological processes involved that may represent a direct link between them. Supporting the possible link between RA and PD, there is a much higher prevalence of RA in PD patients (almost 4%, compared to 1% in the general population). Increases in erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) observed in patients with severe forms of RA correlate with more severe periodontal bone resorption.

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Furthermore, some environmental factors (smoking) and genetic background (genetic polymorphisms) are also considered common risk factors for both diseases.[2] Some periodontopathogenic bacteria such as *Porphyromonas gingivalis* and *Aggregatibacter actinomycetemcomitans* have been related to RA. *P. gingivalis* may induce anti-citrullinated protein antibodies that can lead to RA. *A. actinomycetemcomitans* could provoke hypercitrullination at the neutrophil level by secreting leukotoxin A and inducing the release of hypercitrullinated autoantigens, triggering an autoimmune response in RA patients.[3] Different findings highlight this possible relationship: (a) patients with RA have a higher PD incidence, (b) periodontal patients with RA have a greater ESR and higher CRP levels, and (c) antibodies against periodontal pathogens have been found in the synovial membranes of RA patients.[4]

This study aimed to assess the possible bidirectional link between RA and PD.

MATERIALS AND METHODS

A search was carried out for case–control studies on RA and PD in the next databases: PubMed (MEDLINE, Cochrane Library), Web of Science (WoS), and Google Scholar. Search strategies included the following Medical Subjects Headings (MeSH) and free-text terms: ("rheumatic diseases" [MeSH Terms] OR "arthritis, rheumatoid") AND "periodontal diseases" [MeSH Terms] AND "case-control studies" [MeSH Terms]); ("periodont *" AND "rheumatoid arthritis" AND "case-control"); allintitle: "rheumatoid arthritis" ("periodontal" OR "periodontitis") "case." After the initial search, 364 articles were found (106 in PubMed, 231 in WoS, and 27 in Google Scholar) between 1976 and 2019, 123 of them duplicates, leaving 241 articles to review. Two authors (Alberto Rodriguez-Archilla and Annalisa Vacca-Moreno) independently reviewed the titles and abstracts of the articles and then jointly selected the studies to be included in this meta-analysis. The exclusion criteria were as follows: (a) articles without full-text availability (n = 53), (b) articles with a score of fewer than 6 stars out of a maximum of 9 on the Newcastle-Ottawa Methodological Quality Assessment Scale[5] (n = 62), (c) articles that were not case–control studies (n = 48), and (d) studies with non-usable data (n = 56). Finally, 22 studies were considered in the meta-analysis [Figure 1].

Statistical analysis

For the meta-analysis, the data were processed with the RevMan 5.4 program (The Cochrane Collaboration, Oxford, UK). For continuous outcomes, the estimates of effects of the intervention were expressed as mean differences (MDs) using the inverse variance method and for dichotomous outcomes, the odds ratio (OR) with the Mantel-Haenszel Chi-square formula, both with 95% confidence intervals (95% CI) was used. Heterogeneity was determined according to the P values and the Higgins statistic (I^2). When the heterogeneity was high (I^2 >50%), the random-effects model was applied. P values below 0.05 were set as the minimum level of significance.

RESULTS

The main descriptive characteristics and the methodological quality according to the Newcastle-Ottawa Scale (NOS) of 22 studies[6-27] that relate RA to PD are shown in Table 1.

A total of 3329 individuals, 1556 RA patients (46.1%), 1302 healthy controls (39.1%), and 471 periodontitis individuals (14.2%) were considered in the 22 studies. By gender, 1246 women (80.1%) and 310 men (19.9%) were found in the group of RA patients; 967 women (74.3%) and 335 men (25.7%) in healthy controls and 325 women (69.0%) and 146 men (31.0%) among periodontitis patients. Only articles with low-to-moderate risk of bias (≥6 stars) by the NOS[5] Quality Scale were included in the present study. Eight articles (36.4%), respectively, had 6 and 7 points on the NOS scale, five articles (22.7%) reached 8 points, and one article (4.5%) obtained the maximum score of 9 points.

Table 2 presents the analysis of different periodontal parameters in RA patients and controls without the disease.

Thirteen studies[6,8,10,14,16-20,23,23,25,27] analyzed the plaque index (PI). RA patients had mean PI scores, 0.10 units higher than the participants without the disease, with a highly significant statistical relationship (MD = 0.10; 95% CI: 0.05–0.16; P < 0.001).

Seven studies[6,8,13,18,22,23,27] examined the gingival index (GI), finding mean GI values, 0.31 points higher in RA patients compared to the control group, with a highly significant statistical association (MD = 0.31; 95% CI: 0.17–0.45; P < 0.001).

Other 15 studies[6-9,13-20,23,25,27] evaluated the probing depth (PD), observing a mean PD of 0.45 mm in RA patients greater than that found in the controls. Highly significant statistical differences were found (MD = 0.45; 95% CI: 0.26–0.63; P < 0.001).

Respect to the clinical attachment level (CAL), 16 studies[6-9,13-20,22,23,25,27] revealed a higher mean CAL of 0.59 mm in RA patients, with a highly significant statistical association (MD = 0.59; 95% CI: 0.44–0.74; P < 0.001).

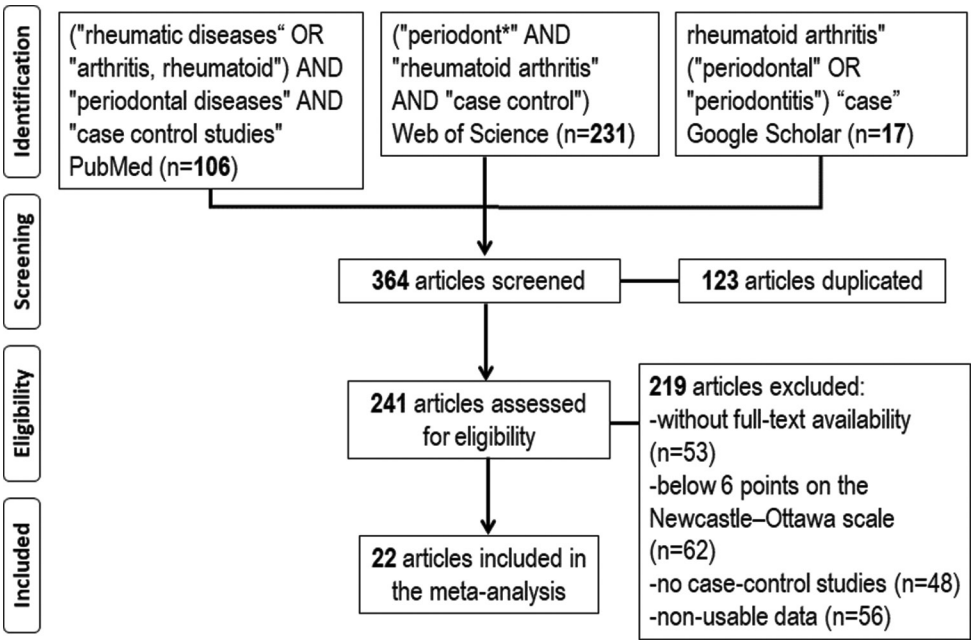

Figure 1: Study flow diagram

Finally, 11 studies[7-10,16-19,23,27] went over the bleeding on probing (BOP), reporting mean BOP values, 8.06 points higher in RA patients versus controls. A highly significant statistical relationship was observed (MD = 8.06; 95% CI 6.80–9.32; $P < 0.001$).

Seven studies[10-12,17,18,25,26] reviewed the possible influence of RA on the number of present teeth. RA patients had, on average, 0.80 fewer teeth than the control group, although without statistically significant differences (MD = −0.80; 95% CI:-2.22-0.63; $P = 0.27$).

Another eight studies[7-9,13,16,19,24,27] observed the possible relationship between RA and the number of missing teeth, finding a mean number of 2.70 more missing teeth in RA patients. The statistical analysis noted a highly significant association (MD = 2.70; 95% CI: 1.89–3.50; $P < 0.001$).

Eight studies[11,13,15,18,21,24-26] assessed the possible impact of RA on the presence of both moderate and severe periodontitis. Regarding moderate periodontitis, RA patients were 2.90 times more likely to moderate periodontitis, with a highly significant statistical relationship (OR = 2.90; 95% CI: 1.32–6.38; $P = 0.008$). Concerning severe periodontitis, RA patients also increased 2.78-fold the probability of severe periodontitis, with statistically significant differences (OR = 2.78; 95% CI: 1.27–6.07; $P = 0.01$).

DISCUSSION

In the present meta-analysis, data from 22 studies have been included to evaluate the possible link between RA and PD.

In this study, RA patients presented a PI of 0.10 units higher than control subjects, with a highly significant statistical relationship ($P < 0.001$). Of the 13 studies that measured this index, 11[6,8,10,14,16-18,20,23,25,27] found higher plaque rates in RA patients and the remaining two studies[19,22] had neutral results. Almost 16% of RA patients have some degree of functional disability in their upper extremities that provokes a lower dexterity of the hands with the toothbrush, bad oral hygiene, and the accumulation of dental plaque.[27] This increased plaque among RA patients could also be the result of the chronic problems that these patients experience in the joints of the hands and wrists, making proper tooth brushing difficult. Bacterial plaque injures gingival tissues and increases the periodontal risk associated with RA.[20] However, other authors do not attribute such a relevant role to poor oral hygiene in RA patients, pointing out that oral hygiene may only partially explain this association and that other further parameters would be responsible for the higher prevalence of the PD in RA patients.[8]

In the present investigation, RA patients had a GI of 0.31 points higher than that of the controls, with a highly significant statistical association ($P < 0.001$). Of the seven studies that analyzed this parameter, five of them[6,8,13,18,27] found a higher GI in RA patients; one,[23] higher in the controls, and another,[22] obtained a neutral result without being in favor of either of the two groups. RA patients showed higher mean gingival indices than the controls without the disease, suggesting a possible relationship between RA and periodontal abnormalities.[27] Moreover, the severity of gingival inflammation established with the

Table 1: Descriptive characteristics of 22 articles included in this study

First author	Year	Country	Study groups	Parameters measured	NOS
Bozkurt[6]	2006	Turkey	17 RA (5 male, 12 female, $\bar{x}$=47.1 years) 17 PP (11 male, 6 female, $\bar{x}$=43.8 years) 17 HC (9 male, 8 female, $\bar{x}$=36.2 years)	PI, GI, PD, CAL	6
Kobayashi[7]	2007	Japan	100 RA (20 male, 80 female, $\bar{x}$=50.8 years) 100 PP (29 male, 71 female, $\bar{x}$=50.7 years) 100 HC (34 male, 66 female, $\bar{x}$=50.9 years)	Tobacco, missing teeth, PI, PD, CAL, BOP	8
Pischon[8]	2008	Germany	57 RA (8 male, 49 female, $\bar{x}$=52.1 years) 52 HC (9 male, 43 female, $\bar{x}$=52.1 years)	Missing teeth, PI, GI, PD, CAL, BOP	7
Kobayashi[9]	2009	Japan	153 RA (27 male, 126 female, $\bar{x}$=52.8 years) 117 PP (31 male, 86 female, $\bar{x}$=51.9 years) 108 HC (35 male, 73 female, $\bar{x}$=51.2 years)	Tobacco, missing teeth, PI, PD, CAL, BOP	8
Mirrielees[10]	2010	USA	35 RA (8 male, 27 female, $\bar{x}$=46.8 years) 35 PP (10 male, 25 female, $\bar{x}$=44.2 years) 35 HC (9 male, 26 female, $\bar{x}$=43.0 years)	Tobacco, alcohol, teeth present, PI, BOP	6
de Smit[11]	2012	Netherlands	95 RA (30 male, 65 female, $\bar{x}$=56.0 years) 44 PP (19 male, 25 female, $\bar{x}$=54.0 years) 36 HC (16 male, 20 female, $\bar{x}$=34.0 years)	Teeth present	7
Ishida[12]	2012	Japan	30 RA (3 male, 27 female, $\bar{x}$=60.0 years) 30 PP (10 male, 20 female, $\bar{x}$=62.3 years) 30 HC (10 male, 20 female, $\bar{x}$=53.4 years)	Tobacco, teeth present, PD, CAL	6
Joseph[13]	2013	India	100 RA (24 male, 76 female, $\bar{x}$=46.5 years) 112 HC (26 male, 96 female, $\bar{x}$=45.9 years)	Tobacco, missing teeth, GI, PD, CAL	7
Sezer[14]	2013	Turkey	40 RA (6 male, 34 female, $\bar{x}$=44.2 years) 20 PP (6 male, 14 female, $\bar{x}$=45.5 years) 20 HC (6 male, 14 female, $\bar{x}$=43.7 years)	PI, PD, CAL, BOP	6
Susanto[15]	2013	Indonesia	75 Ra (15 male, 60 female, $\bar{x}$=46.5 years) 75 Hc (15 male, 60 female, $\bar{x}$=46.9 years)	Tobacco, PD, CAL, periodontitis	7
Wolff[16]	2014	Germany	22 RA (7 male, 15 female, $\bar{x}$=51.7 years) 22 HC (7 male, 15 female, $\bar{x}$=51.9 years)	Tobacco, alcohol, missing teeth, PI, PD, CAL, BOP	6
Yokoyama[17]	2014	Japan	20 RA (2 male, 18 female, $\bar{x}$=54.2 years) 10 PP (1 male, 9 female, $\bar{x}$=56.5 years) 10 HC (3 male, 7 female, $\bar{x}$=56.1 years)	Tobacco, teeth present, PD, CAL, BOP	6
Choi[18]	2016	South Korea	264 RA (33 male, 231 female, $\bar{x}$=58.2 years) 88 HC (11 male, 77 female, $\bar{x}$=58.2 years)	Tobacco, teeth present, PI, PD, CAL, BOP, periodontitis	8
Javed[19]	2016	Saudi Arabia	50 RA (15 male, 35 female, $\bar{x}$=62.5 years) 50 PP (15 male, 35 female, $\bar{x}$=59.7 years)	Teeth missing, PI, PD, CAL, BOP	7
Silvestre-Rangil[20]	2016	Spain	73 RA (21 male, 52 female, $\bar{x}$=53.3 years) 73 HC (24 male, 49 female, $\bar{x}$=52.6 years)	Tobacco, PI, PD, CAL, BOP	7
Ayravainen[21]	2017	Finland	81 RA (13 male, 35 female, $\bar{x}$=51.5 years) 43 HC (5 male, 38 female, $\bar{x}$=56.0 years)	Tobacco, alcohol, teeth present, periodontitis	8
Balci Yuce[22]	2017	Turkey	17 RA (6 male, 11 female, $\bar{x}$=51.0 years) 18 PP (9 male, 9 female, $\bar{x}$=49.5 years) 18 HC (9 male, 9 female, $\bar{x}$=48.8 years)	PI, GI, CAL	6
Kurgan[23]	2017	Turkey	15 RA (6 male, 9 female, $\bar{x}$=49.3 years) 15 HC (7 male, 8 female, $\bar{x}$=42.1 years)	PI, GI, PD, CAL, BOP	6
Ouédraogo[24]	2017	Burkina Faso	43 RA (9 male, 34 female, $\bar{x}$=46.5 years) 86 HC (21 male, 65 female, $\bar{x}$=46.3 years)	Teeth missing, periodontitis	7
Unriza-Puin[25]	2017	Colombia	100 RA (30 male, 70 female, $\bar{x}$=37.3 years) 200 HC (60 male, 140 female, $\bar{x}$=37.5 years)	Tobacco, teeth present, PI, PD, CAL	8
Kaneko[26]	2018	Japan	40 RA (6 male, 34 female, $\bar{x}$=59.9 years) 30 PP (5 male, 25 female, $\bar{x}$=55.5 years) 43 HC (6 male, 37 female, $\bar{x}$=57.6 years)	Tobacco, teeth present, PI, PD, CAL, BOP	9
Zhao[27]	2019	China	128 RA (16 male, 113 female, $\bar{x}$=44.3 years) 109 HC (13 male, 96 female, $\bar{x}$=44.3 years)	Tobacco, teeth missing, PI, GI, PD, CAL, BOP	7

NOS: Newcastle-Ottawa Quality Scale, USA: United States of America, PP: Periodontitis patients, RA: Rheumatoid arthritis, HC: Healthy controls, $\bar{x}$: Mean age, PI: Plaque index, GI: Gingival index, PD: Probing depth, CAL: Clinical attachment level, BOP: Bleeding on probing

GI and BOP, correlates with a longer duration of RA. This suggests that systemic inflammation in RA affects the degree of periodontal inflammation and that certain characteristics of the inflammatory response may be common in both diseases.[18] In both conditions, a persistent inflammatory reaction occurs in the connective tissue and bone, with activation of complement components, production of cytokines, and release of other inflammatory mediators.[23]

In this study, RA patients had a PD of 0.45 mm higher than that of the controls with highly significant statistical differences ($P < 0.001$). Of the 15 studies that evaluated PD, 11[6-9,13,16,18-20,23,25,27] confirmed this greater PD in RA

Table 2: Analysis of different periodontal parameters in rheumatoid arthritis patients and controls without the disease

Parameter	*n*	Outcome	MD/OR	95% CI	I^2 (%)	*P*
PI	13	RA patients	MD: 0.10	0.05-0.16	76	<0.001*
GI	7	RA patients	MD: 0.31	0.17-0.45	83	<0.001*
PD	15	RA patients	MD: 0.45	0.26-0.63	98	<0.001*
CAL	16	RA patients	MD: 0.59	0.44-0.74	97	<0.001*
BOP	11	RA patients	MD: 8.06	6.80-9.32	90	<0.001*
Number of present teeth	7	RA patients	MD: −0.80	−2.22-0.63	93	0.27
Number of missing teeth	8	RA patients	MD: 2.70	1.89-3.50	98	<0.001*
Moderate periodontitis	8	RA patients	OR: 2.90	1.32-6.38	91	<0.01*
Severe periodontitis	8	RA patients	OR: 2.78	1.27-6.07	78	0.01*

*Statistically significant. n: Number of studies, MD: Mean difference, OR: Odds ratio, CI: Confidence interval, I^2: Higgins statistic for heterogeneity (percentage). RA: Rheumatoid arthritis, PI: Plaque index, GI: Gingival index, PD: Probing depth, CAL: Clinical attachment level, BOP: Bleeding on probing

patients while three of them[14,15,17] did not observe it. This greater PD in patients with RA could be explained by poor oral hygiene with an accumulation of dental plaque and the appearance of pathological periodontal changes that favor the development of periodontal pockets.[20] Moreover, It should take into account the medication of RA patients. These patients usually take nonsteroidal anti-inflammatory drugs (NSAIDs), medications that inhibit inflammatory destruction in PD. Nevertheless, in RA patients, these drugs do not improve periodontal parameters compared to individuals without the disease. Probably, apart from the degree of oral hygiene, other factors influence this periodontal worsening in RA patients, such as lower socioeconomic and educational levels that would make patients neglect their oral and systemic health, making them more prone to PD.[19]

In the present article, RA patients showed a CAL of 0.59 mm higher, with a highly significant statistical association ($P < 0.001$). Of the 16 studies that investigated this parameter,[6-9,13,16,18-20,22,23,25,27] agreed to indicate a greater CAL in RA patients while three,[14,15,17] did not find this greater CAL. Most of the periodontal parameters (PI, GI, PD and CAL) were significantly worse in RA patients, highlighting their worse periodontal status. RA patients were at increased risk for both PD and more advanced forms (moderate-severe) of periodontitis.[27] Similarly, RA patients, due to their inflammatory disorder, have high levels of CRP, with a direct correlation between CRP levels and CAL. Moreover, RA patients suffer from more severe periodontitis, and there must be a common genetic predisposition since both RA and severe periodontitis are related to similar histocompatibility antigens haplotypes. Both disorders cause a dysregulation of the host's immune-inflammatory response. RA may induce a higher CAL by increasing levels of cytokines and metalloproteinases (MMPs) in gingival tissues.[13]

In this study, RA patients had a BOP 8.06 points higher than that observed in controls, with a highly significant statistical relationship ($P < 0.001$). All studies[7-10,14,16-19,23,27] on this periodontal parameter also observed a greater BOP in RA patients. Several studies state the importance of the inflammatory reaction in the evolution of both RA and PD. A strong positive correlation has been found between inflammation-induced gingival crevicular fluid volume increase and increased BOP parameter.[23] Parallelism has also been observed between the duration of RA and increased BOP, suggesting that systemic inflammation in RA could affect the degree of periodontal inflammation.[18] In RA patients with a higher BOP, an increase in the levels of pro-inflammatory cytokines such as interleukin 1 beta (IL-1β), IL-6, IL-17, or tumor necrosis factor-alpha (TNF-α) is observed. These high cytokine levels worsening periodontal inflammatory status and ultimately causing a greater marginal bone loss.[19]

In the present study, there were no statistically significant differences ($P = 0.27$) between RA patients and controls regarding the mean number of present teeth. Of the 7 studies that assessed this variable, five[10-12,18,26] observed a slightly lower number of teeth in RA patients; one study,[25] found more teeth in RA patients and another one[17] obtained a neutral result. On the other hand, RA patients had a mean number of 2.70 more missing teeth compared to controls, with a highly significant association ($P < 0.001$). Eight studies[7-9,13,16,19,24,27] showed a greater number of missing teeth in RA patients. These patients have a greater tooth loss, probably related to the presence of more bacterial plaque, a greater depth of periodontal pockets, and a higher loss of periodontal attachment.[27] Furthermore, RA patients tend to have poorer PI, GI, PD, CAL, and BOP indicators, along with a greater number of missing teeth.[20] Nevertheless, some studies found no statistically significant differences in the number of missing teeth between RA patients and individuals without the disease. The NSAIDs intake by RA patients could justify a lower rate of gingivitis and tooth loss. The NSAIDs could exercise a protective influence on bone loss and preventive action on subsequent

tooth loss.[13] Other authors explain this greater tooth loss in RA patients in causes other than the disease itself, such as a greater number of extracted teeth with advanced caries in RA patients.[9]

In this paper, RA patients were 2.90 times more likely to have moderate periodontitis compared to controls, with a statistically significant relationship ($P = 0.008$). Of the eight studies that examined moderate periodontitis, six of them,[11,13,18,21,24,25] found a higher prevalence of moderate periodontitis in RA patients, and two studies,[15,26] higher moderate periodontitis prevalence in controls. Similarly, RA patients also increased 2.78-fold the probability of severe periodontitis, with statistically significant differences ($P = 0.01$). Eight studies[11,13,15,18,21,24,25] assessed severe periodontitis, also finding a higher severe periodontitis prevalence in RA patients while, only one,[26] did not observe it in RA patients. This higher predisposition of RA patients to both moderate and severe periodontitis could be explained because both diseases share inflammatory mechanisms that lead to the overproduction of prostaglandin E2 (PGE2) in response to bacterial lipopolysaccharides. The secretion of this inflammatory mediator is associated with greater severity of both RA and PD.[13] Both chronic inflammatory disorders also present high levels of pro-inflammatory cytokines such as IL-1β, IL-6, and TNF-α, of MMPs and PGE2, and low levels of anti-inflammatory cytokines such as IL-10, tumor growth factor-beta (TGF-β) and tissue inhibitor of MMPs. All of these cytokines are associated with tissue destruction in these diseases.[13] The higher severity of periodontitis is related to a sustained state of daily bacteremia that contribute to systemic inflammation. Chronic RA patients with severe periodontitis have been found to show the highest CRP levels.[21] On the contrary, other studies do not observe this higher prevalence and severity of periodontitis in RA patients. This finding could be explained by the use of powerful anti-inflammatory drugs in RA patients, such as corticosteroids and NSAIDs. These drugs inhibit the activity of pro-inflammatory proteins, such as cyclooxygenase 2 (COX-2), IL-1, IL-2 and IL-6, TNF-α, and cell adhesion molecules. RA patients also take different anti-rheumatoid drugs (methotrexate, sulfasalazine, chloroquine, or leflunomide) that reduce the inflammatory response in RA. Methotrexate in combination with prednisolone reduces blood levels of IL-1β and IL-6, blocks free radical-mediated processes, and lessen inflammation in both RA and PD.[15]

Study limitations

In many studies, periodontitis was classified as mild/moderate/severe; while, others only contemplated chronic periodontitis without calibrating its severity. Aggressive periodontitis was not taken into account either.

The influence of drug treatment of RA could not be adequately assessed on the progress of both entities (RA and PD). Moreover, some studies did not consider smoking habit, a relevant confounding factor for both periodontitis and RA.

The results of this meta-analysis should be interpreted with caution due to the high heterogeneity observed in some comparisons. Individual differences between studies may be related to the study design type, the different diagnostic criteria used or the particular characteristics of the study populations.

New studies are needed to provide more evidence to the bidirectional link between two chronic inflammatory diseases such as RA and PD.

CONCLUSIONS

In this meta-analysis, RA patients showed higher levels of: PI (MD: 0.10; $P < 0.001$); GI (MD: 0.31; $P < 0.001$); PD (MD: 0.45; $P < 0.001$); clinical attachment loss (MD: 0.59; $P < 0.001$) and BOP (MD: 8.06; $P < 0.001$). They also had a lower number of present teeth (MD:-0.80; $P = 0.27$) and a greater number of missing teeth (MD: 2.70; $P < 0.001$). RA patients had a higher risk of both moderate (OR: 2.90; $P = 0.008$) and severe periodontitis (OR: 2.78; $P = 0.01$).

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Conflicts of interest

There are no conflicts of interest.

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