Community Dental Health (2023) **40** 47–52
Received 14 August 2022; Accepted 7 November 2022

doi:10.1922/CDH_00180Xu06

Is There An Association Between Periodontitis And Non-Alcoholic Fatty Liver Disease? A Systematic Review and Meta-Analysis

Feiyan Xu[1] and Jimei Tang[2]

[1]*Department of Stomatology, Shangyu People's Hospital of Shaoxing, Shaoxing, China;* [2]*Department of Endocrinology, Shangyu People's Hospital of Shaoxing, Shaoxing, China*

Background: Studies have reported varying relationships between periodontitis and non-alcoholic fatty liver disease (NAFLD). This review aimed to summarise evidence by pooling published data on the association between periodontitis and NAFLD. ***Methods***: PubMed, CENTRAL, Web of Science, and Embase databases were searched for cross-sectional, case-control, or cohort studies published up to 20th June 2022. The PICO statement was: In the general *Population* does the presence of periodontitis (*Intervention*) as compared to no periodontitis (*Comparison*) lead to NAFLD (*Outcome*). All included studies were to report the association between periodontitis and NAFLD using odds ratios (OR) or risk ratios with 95% confidence intervals (CI). Random effects meta-analysis was conducted to obtain pooled OR with 95% CI. *Results*: Meta-analysis of seven studies with data of 192,815 participants found no association between periodontitis and NAFLD (OR: 1.04 95% CI: 0.97, 1.12). There was medium heterogeneity in the meta-analysis (I^2=58%). The results did not change with the exclusion of any study. A small risk of NAFLD was noted in periodontitis patients on analysis of two cohort studies. Results were non-significant for other study types. Subgroup analysis based on the study population and diagnostic method for NAFLD also failed to find relationships. *Conclusion*: Current evidence fails to demonstrate a link between periodontitis and NAFLD.

Keywords*: Periodontitis, systemic diseases, fatty liver, oral*

Introduction

Periodontitis is a common chronic multifactorial inflammatory disease that leads to the destruction of tooth-supporting connective tissue and alveolar bone (Knight and Murray Thomson, 2018). In recent years, there has been intense debate on the role of oral, and especially periodontal diseases as a cause of systemic illness (Somma *et al*., 2010), with research showing that periodontitis may be a risk factor for cardiac, respiratory, and renal disorders (Imai *et al*., 2021; Park *et al*., 2022; Pizzo *et al*., 2010).

Non-alcoholic fatty liver disease (NAFLD) is a common condition with fat deposits in the liver not attributable to alcohol consumption or other causes (Powell *et al*., 2021). NAFLD is closely linked to metabolic syndrome including diabetes, hypertension, and obesity with which it shares a bidirectional relationship. A common pathophysiological pathway consisting of oxidative stress and the chronic inflammatory response has been implicated in both disorders (Huang *et al*., 2020). Since periodontitis also generates a chronic inflammatory response, research has likened it with NAFLD. Animal studies have shown that periodontitis in rat models was associated with liver steatosis, inflammation and sinusoidal fibrosis (Tomofuji *et al*., 2007). Human studies have also demonstrated a positive association between periodontitis and NAFLD associated with periodontal pathogens, inflammatory mediators, and oxidative stress (Iwasaki *et al*., 2018; Shin *et al*., 2022).

The capability of periodontal infections to cause systemic diseases may stem from superficial ulceration in the gingival sulcus allowing pathogenic bacteria or their toxins translocate into the systemic circulation (D'Aiuto *et al*., 2004; Forner *et al*., 2006; Tomás *et al*., 2012). *Porphyromonas gingivalis (P. gingivalis)*, a major causative agent for periodontitis, is found in higher proportions in patients with NAFLD as compared to controls, suggesting its role in the development of NAFLD (Yoneda *et al*., 2012). Translocation of periodontopathogens can also occur into the gut via swallowing, causing changes in the gut microbiota. Alteration of oral flora (as seen in periodontitis) can modify the intestinal microbiota thereby increasing the risk of NAFLD (Wang *et al*., 2022). *P. gingivalis* has been implicated in the alteration of gut microbiota and progression of NAFLD via disruption of several metabolic pathways. Infections with *P. gingivalis* can increase fat deposition, inflammation, and insulin resistance through immune cell-derived inflammatory reactions and different intracellular signaling pathways (Hatasa *et al*., 2021; Wang *et al*., 2022).

Considering these pathophysiological mechanisms, it is suggested that patients with periodontitis may have a heightened risk of NAFLD and timely and aggressive therapy may aid in the prevention of the condition (Shin *et al*., 2022). However, results from clinical studies have been inconsistent and it is unclear if there is a causal relationship between the two entities. Wijarnpreecha et al. (2020) published a meta-analysis on this topic, but

Correspondence to: Jimei Tang Email: dashanxia1982@126.com

their review included only five studies with only 27,703 participants. Their review found no association periodontitis and NAFLD, however, subsequent primary studies have shown contradictory results (Duseja *et al*., 2021; Shin *et al*., 2022). Considering such conflicting evidence, we aimed to combine data from all published studies to determine if periodontitis leads to increased risk of NAFLD.

Methods

The review began with prior registration on PROSPERO (CRD42022340272). A detailed literature search was conducted on the PubMed, CENTRAL, Web of Science, and Embase databases for studies published from the inception of the databases up to 20th June 2022 and examined the association between periodontitis and NAFLD. The search was restricted to English language publications only but without any limitation on the date of publication. Gray literature was searched using Google Scholar. The PICO statement was: In the general *Population* does the presence of periodontitis (*Intervention*) as compared to no periodontitis (*Comparison*) lead to NAFLD (*Outcome*).

Studies eligible for the review were either cross-sectional, case-control, or cohort studies. Cohort studies were to follow up a group of individuals with and without periodontitis and examine the risk of incidental NAFLD. Case-control studies were to compare a group of NAFLD with healthy individuals and explore the history of periodontitis in each group. Cross-sectional studies were to examine the simultaneous presence of periodontitis and NAFLD in the study participants. All studies were to report the association between periodontitis and NAFLD using odds or risk ratios with 95% confidence intervals (CI).

We excluded studies using the same databases in separate articles. In such cases, the study presenting the most compressive data were selected for inclusion. Studies not exclusively on NAFLD and including other liver pathologies were excluded. Review articles, case reports, and editorials were also not considered. The PRISMA statement guidelines were followed (Page *et al*., 2021).

A mix of free-text and MeSH search terms was incorporated for the search including: "NAFLD", "non-alcoholic fatty liver disease", "steatohepatitis"; "fatty liver", "periodontitis"; and "periodontal disease". The search string used was ((((non-alcoholic fatty liver disease) OR (NAFLD)) OR (steatohepatitis)) OR (fatty liver)) AND (periodontal disease OR periodontitis). The search results were deduplicated and scrutinised based on the eligibility criteria independently by both authors, first using titles and abstracts and then the full-texts. Articles completing all eligibility criteria were included. Any disagreements were solved by consensus. The references of included studies were cross-checked for additional articles.

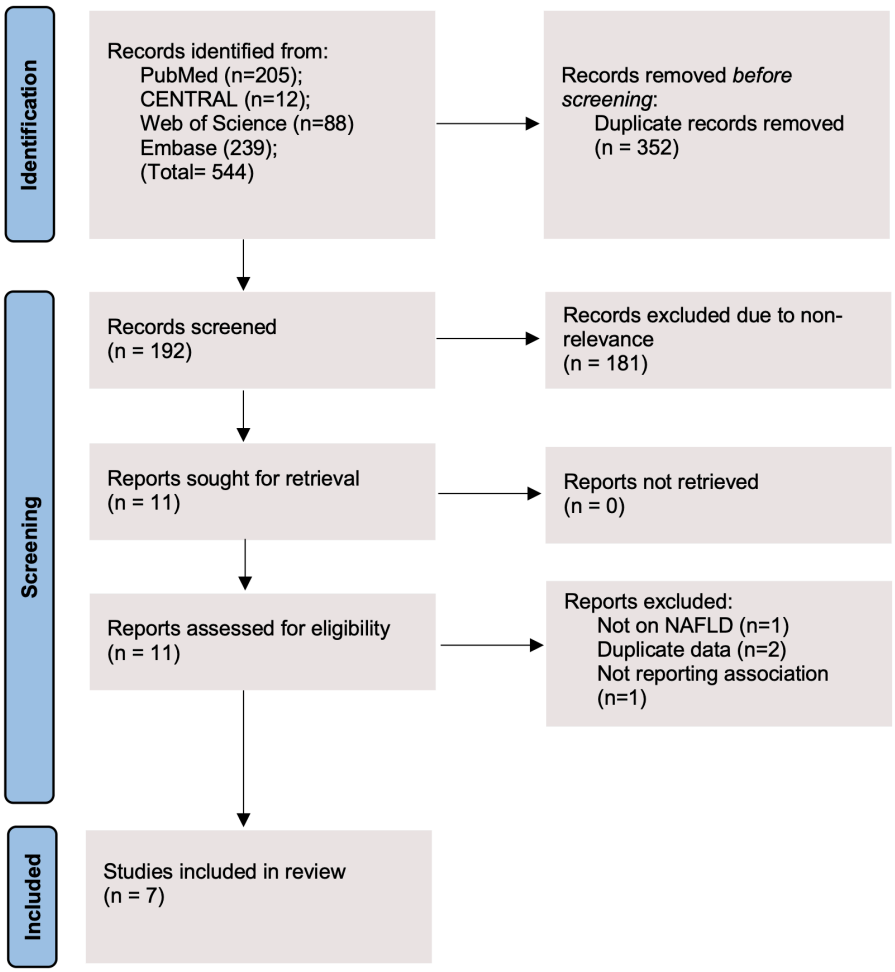

Figure 1. *Study flow chart.*

Data on the study authors, year of publication, study location and database, study type, sample size, mean age, diagnosis of periodontitis and NAFLD, factors adjusted for the results, and outcome ratios were extracted by two reviewers independently.

The Newcastle Ottawa Scale (NOS)(Wells *et al*., 2021) was used to score the risk of bias in the observational studies on three domains: selection of study population, comparability, and assessment of outcomes/exposure. These domains were given maximum of four, two and three stars respectively, according to the preformatted questions (total score range = 0-9). Studies with nine points were considered to have a low risk, seven to eight points moderate risk and those with scores of six and below a high risk of bias.

"Review Manager" (RevMan, version 5.3; Nordic Cochrane Centre (Cochrane Collaboration), Copenhagen, Denmark; 2014) was used for meta-analysis. Effect sizes were extracted from all the included studies and pooled to generate the total results as odds ratio (OR) with 95% CI in random-effects models. Inter-study heterogeneity was assessed using I^2. I^2=25-50% meant low, 50-75% meant medium, and more than 75% meant substantial heterogeneity. Funnel plots were used to detect publication bias. A leave-one-out analysis was performed to check for any change in the results on the exclusion of any study. Subgroup analyses was also performed based on study location (Asian or Western), study type (cohort or cross-sectional), and diagnostic modality of NAFLD (ultrasonography or other markers).

Results

In total, 544 sources were identified and retrieved, of which 352 were duplicates (Figure 2). Eleven were eligible for full-text review, four of which were excluded, leaving seven (Akinkugbe *et al*., 2017, 2018; Alazawi *et al*., 2017; Duseja *et al*., 2021; Iwasaki *et al*., 2018; Shin, 2020; Shin *et al*., 2022) included in the review.

The studies were published between 2017 and 2022 (Table 1). They were conducted in the USA, Germany, Japan, South Korea or India. Two were retrospective cohort studies (Akinkugbe *et al*., 2017; Shin *et al*., 2022), one was a case-control study (Duseja *et al*., 2021) and the remaining were cross-sectional. Sample sizes ranged from 80 to 165,032 participants. Except for one study (Shin *et al*., 2022) that used International Classification of Diseases (ICD) codes, all other studies diagnosed periodontitis based on clinical attachment levels or pocket depths. Three studies (Akinkugbe *et al*., 2017, 2018; Alazawi *et al*., 2017) reported outcomes based on both diagnostic criteria of periodontitis: clinical attachment levels and pocket depth. To maintain homogeneity between studies, pocket depth data were used for the meta-analysis. The diagnosis of NAFLD was based on either ultrasonographic findings, liver enzyme analysis, or fatty liver index. One study (Shin *et al*., 2022) did not report the exact diagnostic criteria as NAFLD patients were recognized from the database using ICD codes. Different confounders were adjusted for (Table 1).

Including all seven studies with data of 192,815 participants our meta-analysis found no association between periodontitis and NAFLD (OR: 1.04, 95% CI: 0.97, 1.12) (Figure 2). There was medium heterogeneity in the meta-analysis with I^2=58%. The funnel plot did not indicate any publication bias (data available on request). On leave-one-out analysis, no change was noticed in the significance of results on the exclusion of any study.

Table 2 summarises the results of subgroup analyses. There was no association between periodontitis and NAFLD in studies from different regions. Meta-analysis of two cohort studies found a small increase in risk of NAFLD in patients with periodontitis, which was absent in cross-sectional and the lone case-control study. Nor did the diagnostic modality of NAFLD impact the results. Likewise, no differences were found between studies using ultrasonography for NAFLD diagnosis and studies using other markers.

Six studies had moderate risk of bias with NOS scores of 8 (Table 3). The report for Duseja et al. (2021) was considered to have high risk of bias.

Discussion

Hitherto, the link between periodontitis and NAFLD has been based on the role of periodontal pathogens, systemic inflammation and oxidative stress (Iwasaki *et al*., 2018; Shin *et al*., 2022). The periodontal pathogen *P. gingivalis* may also be a factor in the pathology of NAFLD by either translocation via the bloodstream or gut (Yoneda *et al*., 2012). Considering the potential links between periodontitis and NAFLD, prevention as well as adequate treatment of periodontitis has been proposed to reduce the risk of NAFLD in the general population (Iwasaki *et al*., 2018; Shin *et al*., 2022). However, one must be careful of such conclusions from singular studies as these may not denote causal relationships but could be confounded by other variables. Meta-analysis collates

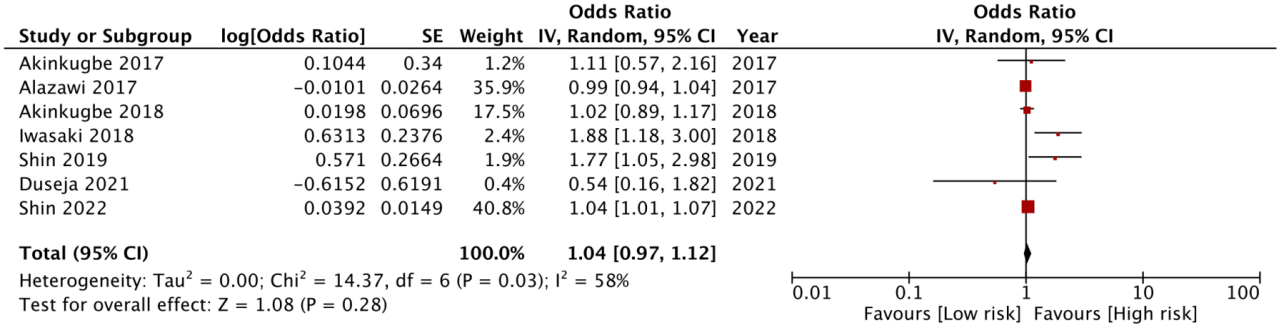

Figure 2. *Meta-analysis of relationship between periodontitis and NAFLD.*

Table 1. Details of included studies.

Study	*Location*	*Study type*	*Sample size*	*Diagnosis of periodontitis*	*Diagnosis of NAFLD*	*Mean age*	*Adjusted factors*
Shin 2022	South Korea	RC	165,032	ICD codes	ICD codes	NR	Age, gender, household income, smoking, alcohol, physical activity, diabetes, hypertension, obesity, hypercholesterolemia, and ischemic heart disease
Duseja 2021	India	CC	80	Presence of either CAL or PD ≥ 4 mm and bleeding on probing	Ultrasound findings of hepatic steatosis with at least 1.5 times increased levels of liver enzymes	36	NR
Shin 2019	South Korea	CS	4061	PD ≥ 3.5 mm	FLI score of >60% and HSI >36%	NR	Age, income, education, smoking, alcohol, physical activity, diabetes, obesity, hypertension and hypercholesterolemia
Iwasaki 2018	Japan	CS	1226	PD ≥ 4 mm	Ultrasound findings of hepatic steatosis without secondary causes of hepatic fat accumulation	50	Gender, age, BMI, present teeth, HbA1C, total cholesterol, triglyceride, HDL, LDL, SBP, DBP and CRP
Akinkugbe 2018	USA	CS	11914	Presence of either CAL ≥ 3 mm or PD ≥ 4 mm	FLI score of ≥ 60%	40.4	Age, gender, obesity, smoking, diabetes, physical activity, education and acculturation
Alazawi 2017	USA	CS	8172	Presence of either CAL ≥ 3 mm or PD ≥ 4 mm	Ultrasound findings of hepatic steatosis without secondary causes of hepatic fat accumulation	NR	Gender, age, ethnicity, poverty income ratio, education, diet, smoking, diabetes, hypertension, cholesterol and BMI
Akinkugbe 2017	Germany	RC	2330	Presence of either CAL ≥ 3 mm or PD ≥ 4 mm	Ultrasound findings of hepatic steatosis without secondary causes of hepatic fat accumulation or elevated serum ALT without other causes of liver injury.	46	Age, waist circumference, BMI, alcohol, education, smoking, diabetes and physical activity

BMI, body mass index; CAL, clinical attachment level; CRP, C-reactive protein; CC, case-control; CS, cross-sectional; DBP, diastolic blood pressure; FLI, fatty liver index; HbA1C, hemoglobin A1C; HDL, high-density lipoprotein; HIS, hepatic steatosis index; ICD, international classification of diseases; LDL, low-density Lipoprotein; NAFLD, non-alcoholic fatty liver disease; NHANES, United States National Health and Nutrition Examination Survey; PD, probe pocket depth; RD, retrospective cohort; SBP, systolic blood pressure

Table 2. Subgroup analyses.

Variable	*Groups*	*No. studies*	*Odds ratio (95% CI)*
Location	Asian	4	1.31 (0.85, 2.0)
	Western	3	0.99 (0.95, 1.04)
Study type	Cohort	2	1.04 (1.01, 1.07)
	Cross-sectional	4	1.15 (0.95, 1.38)
	Case-control	1	1.54 (0.16, 1.82)
Diagnosis of NAFLD	Ultrasonography	4	1.15 (0.77, 1.71)
	Other markers	3	1.06 (0.95, 1.18)

data from multiple sources to obtain the best possible estimate of a relationship. We pooled data from seven published studies including 192,815 participants and found no association between the two diseases. People with periodontitis do not appear to have greater risk of NAFLD. The validity of our results is supported by no study having a disproportionate effect on the outcomes in leave-one-out analysis. Furthermore, there was no

Table 3. Risk of bias analysis.

Study	*Selection*	*Comparability*	*Assessment of outcome/ exposure*	*Total score*
Shin 2022	****	**	**	8
Duseja 2021	****	-	**	6
Shin 2019	****	**	**	8
Iwasaki 2018	****	**	**	8
Akinkugbe 2018	****	**	**	8
Alazawi 2017	****	**	**	8
Akinkugbe 2017	****	**	**	8

evidence of any publication bias. Wijarnpreecha et al. (2020) also compiled data on the link between the two diseases but with only five studies including only 27,703 participants. Our results reinforce the conclusions of that meta-analysis, but with significantly greater analytic power. Furthermore, our multiple subgroup analyses were missing in the previous study.

One important aspect is that to consider is the total effect size of the results which was 1.04 with the lower end of the 95% CI close to 1. Furthermore, the OR derived in most of the studies was towards a positive association between the two diseases. Thus, the risk of type-2 error cannot be ruled out. Considering the study designs and limitations of individual studies in the diagnosis of both periodontitis and NAFLD, it is plausible that a relationship between the two diseases could not be revealed. However, based on current available data wherein the meta-analysis failed to reveal an association and the subgroup analyses, all of which were non-significant, it is plausible that there is a spurious correlation between periodontitis and NAFLD or that there is residual confounding. Few of the included studies found an association between the two diseases. Furthermore, the effect size of these studies was small, which could influence the overall significance of the results of this meta-analysis.

The prevalence and severity of NAFLD are influenced by ethnicity (Rich *et al*., 2018). However, on separating studies based on the study population, no association between periodontitis and NAFLD could again be found. Study design is also an important factor when assessing the results. In cohort studies, the exposure is identified before the outcome and this temporality adds weight to causal inference. Subgroup analysis of cohort studies showed a 4% greater risk of NAFLD with periodontitis. Considering that there were just two cohort studies in the analysis, the results should be interpreted with caution. Furthermore, the clinical relevance of such a small risk is also questionable. Lastly, studies were also segregated based on the diagnostic criteria of NAFLD. Liver biopsy is the gold standard for diagnosing NAFLD and other approaches can over- or underestimate the prevalence of NAFLD (Huang *et al*., 2020). No relationship between the two diseases could be found whether or not NAFLD was diagnosed with ultrasonography.

There are limitations to our review that need to be considered. Despite a thorough literature search, the number of included studies was not high. The search was limited to English language studies only. While no non-English language studies were found in any database, the literature search cannot be considered complete without a detailed search of language-specific databases. The moderate inter-study heterogeneity could be due to differences in study designs, study populations, and the diagnostic criteria of periodontitis and NAFLD. The variations in diagnostic criteria for periodontal and liver diseases could have masked any relationships, although the sub-analysis by diagnosis of NAFLD does not support this concern. Finally, whilst the source studies adjusted for several confounders, inconsistency in the selection of confounders and residual founding could have led to over-estimates of the relationship between periodontal and liver diseases.

These data have clinical implications. As the data do not support a relationship, no recommendation can be made to screen for periodontitis to prevent NAFLD. However, irrespective of any relationship between periodontitis and NAFLD, periodontitis should be managed in its own right. Further high-quality research should investigate the link between periodontitis and NAFLD in large prospective studies using standard diagnostic criteria for both conditions, taking into account multiple confounding factors.

In conclusion, this meta-analysis found no association between periodontitis and NAFLD. The higher risk of NAFLD noted in prior studies could be due to confounding and does not appear to represent a causal relationship.

Acknowledgements

Not applicable.

Compete Of Interest

The authors declare that they have no competing interests.

Data Availability

The data that support the findings of this study are openly available in [PROSPERO] at [https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022340272], reference number [No CRD42022340272].

References

Akinkugbe, A.A., Barritt, A.S., Cai, J., Offenbacher, S., Thyagarajan, B., Khambaty, T., Singer, R., Kallwitz, E., Heiss, G. and Slade, G.D. (2018): Periodontitis and prevalence of elevated aminotransferases in the Hispanic Community Health Study/Study of Latinos. *Journal of Periodontology* **89**, 949–958.

Akinkugbe, A.A., Slade, G.D., Barritt, A.S., Cole, S.R., Offenbacher, S., Petersmann, A., Kocher, T., Lerch, M.M., Mayerle, J., Völzke, H., Heiss, G. and Holtfreter, B. (2017): Periodontitis and Non-alcoholic Fatty Liver Disease, a population-based cohort investigation in the Study of Health in Pomerania. *Journal of Clinical Periodontology* **44**, 1077–1087.

Alazawi, W., Bernabe, E., Tai, D., Janicki, T., Kemos, P., Samsuddin, S., Syn, W.K., Gilliam, D. and Turner, W. (2017): Periodontitis is associated with significant hepatic fibrosis in patients with non-alcoholic fatty liver disease. *PloS one* **12**, e0185902

D'Aiuto, F., Parkar, M., Andreou, G., Brett, P.M., Ready, D., and Tonetti, M.S. (2004): Periodontitis and atherogenesis: causal association or simple coincidence? *Journal of Clinical Periodontology* **3**, 402–411.

Duseja, A., Chahal, G., Jain, A., Mehta, M., Ranjan, A., and Grover, V. (2021): Association between nonalcoholic fatty liver disease and inflammatory periodontal disease: A case-control study. *Journal of Indian Society of Periodontology* **25**, 47–54.

Forner, L., Larsen, T., Kilian, M., and Holmstrup, P. (2006): Incidence of bacteremia after chewing, tooth brushing and scaling in individuals with periodontal inflammation. *Journal of Clinical Periodontology* **33**, 401–407.

Hatasa, M., Yoshida, S., Takahashi, H., Tanaka, K., Kubotsu, Y., Ohsugi, Y., Katagiri, T., Takanori, I. and Katagiri, S. (2021): Relationship between NAFLD and periodontal disease from the view of clinical and basic research, and immunological response. *International Journal of Molecular Sciences* **22**, 3728.

Huang, T., Behary, J., and Zekry, A. (2020): Non-alcoholic fatty liver disease: a review of epidemiology, risk factors, diagnosis and management. *Internal Medicine Journal* **50**, 1038–1047.

Imai, J., Kitamoto, S., and Kamada, N. (2021): The pathogenic oral-gut-liver axis: new understandings and clinical implications. *Expert Review of Clinical Immunology* **17**, 727–736.

Iwasaki, T., Hirose, A., Azuma, T., Ohashi, T., Watanabe, K., Obora, A., Deguchi, F., Kojima, T., Isozaki, A. and Tomofuji, T. (2018): Correlation between ultrasound-diagnosed non-alcoholic fatty liver and periodontal condition in a cross-sectional study in Japan. *Scientific Reports* **8**, 7496.

Knight, E.T., andThomson, M.W. (2018): A public health perspective on personalized periodontics. *Periodontology 2000* **78**, 195–200.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., et al. (2021): The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *International Journal of Surgery* **88**, 105906.

Park, D.Y., Park, J.Y., Lee, D., Hwang, I., and Kim, H. (2022): Leaky Gum: The Revisited Origin of Systemic Diseases. *Cells* **11**, 1079.

Pizzo, G., Guiglia, R., Russo, L. Lo, and Campisi, G. (2010): Dentistry and internal medicine: from the focal infection theory to the periodontal medicine concept. *European Journal of Internal Medicine* **21**, 496–502.

Powell, E.E., Wong, V.W.S., and Rinella, M. (2021): Non-alcoholic fatty liver disease. *Lancet* **397**, 2212–2224.

Rich, N.E., Oji, S., Mufti, A.R., Browning, J.D., Parikh, N.D., Odewole, M., Mayo, H. and Singal, A.G. (2018): Racial and Ethnic Disparities in Nonalcoholic Fatty Liver Disease Prevalence, Severity, and Outcomes in the United States: A Systematic Review and Meta-analysis. *Clinical Gastroenterology and Hepatology* **16**, 198-210.e2.

Shin, H.S. (2020): Association between periodontal status and non-alcoholic fatty liver disease in a Korean adult population: A nationwide cross-sectional study. *Journal of Periodontology* **91**, 524–532.

Shin, H.S., Hong, M.H., Moon, J.Y., and Sim, S.J. (2022): Periodontal disease could be a potential risk factor for non-alcoholic fatty liver disease: An 11-year retrospective follow-up study. *Clinical Oral Investigations*, In Press.

Somma, F., Castagnola, R., Bollino, D., and Marigo, L. (2010): Oral inflammatory process and general health Part 1: The focal infection and the oral inflammatory lesion. *European Review for Medical and Pharmacological Sciences* **14**, 1085-1095.

Tomás, I., Diz, P., Tobías, A., Scully, C., and Donos, N. (2012): Periodontal health status and bacteraemia from daily oral activities: systematic review/meta-analysis. *Journal of Clinical Periodontology* **39**, 213–228.

Tomofuji, T., Ekuni, D., Yamanaka, R., Kusano, H., Azuma, T., Sanbe, T., Tamaki, N., Yamamoto, T., Watanabe, T., Miyauchi, M. and Takata, T. (2007): Chronic administration of lipopolysaccharide and proteases induces periodontal inflammation and hepatic steatosis in rats. *Journal of Periodontology* **78**, 1999–2006.

Wang, T., Ishikawa, T., Sasaki, M., and Chiba, T. (2022): Oral and Gut Microbial Dysbiosis and Non-alcoholic Fatty Liver Disease: The Central Role of Porphyromonas gingivalis. *Frontiers in Medicine* **9**, 822190.

Wells, G., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., and Tugwell, P. (2021): The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Retrieved October 30, 2020, from http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp

Wijarnpreecha, K., Panjawatanan, P., Cheungpasitporn, W., Lukens, F.J., Harnois, D.M., Pungpapong, S., and Ungprasert, P. (2020): The Association between Periodontitis and Nonalcoholic Fatty Liver Disease: A Systematic Review and Meta-analysis. *Journal of Gastrointestinal and Liver Diseases* **29**, 211–217.

Yoneda, M., Naka, S., Nakano, K., Wada, K., Endo, H., Mawatari, H., Imajo, K., et al. (2012): Involvement of a periodontal pathogen, Porphyromonas gingivalis on the pathogenesis of non-alcoholic fatty liver disease. *BMC gastroenterology* **12**, 16.