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Exploring the link between periodontal disease and sperm quality: a comprehensive systematic review study

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Abstract

Background Periodontal diseases are among the most prevalent oral health conditions globally, with evidence suggesting their systemic effects, including potential impacts on male reproductive health. Inflammation associated with periodontitis might interfere with spermatogenesis and alter sperm parameters such as count, motility, morphology, and DNA integrity. This systematic review aims to critically assess existing studies on the relationship between periodontal disease and sperm quality to delineate its clinical implications for male infertility.

Methods The research was registered in the International Prospective Register of Systematic Reviews (PROSPERO) at the National Institute for Health Research (PROSPERO code: CRD420251005800). A comprehensive literature search was conducted across multiple databases, including PubMed, EMBASE, ProQuest, Scopus, Web of Science (WOS), and Google Scholar, up to September 2024. Inclusion criteria targeted human studies reporting associations between periodontal health and sperm quality parameters. To assess the quality of the included studies, the Newcastle-Ottawa Scale (NOS) was used. Data were synthesized qualitatively and analyzed for trends.

Results Nine studies encompassing 1,386 participants were included. Evidence suggests a significant association between periodontitis and decreased sperm motility, abnormal morphology, and increased DNA fragmentation. However, findings on sperm count and concentration were inconsistent. Mechanistic pathways suggest that inflammatory cytokines and oxidative stress contribute to these disruptions.

Conclusion This review highlights the systemic implications of periodontal disease on male reproductive health. Given the global decline in male fertility, maintaining oral health may serve as an adjunct strategy in managing infertility. Future research should prioritize large-scale, longitudinal studies to establish causality and explore preventive interventions.

Keywords Periodontal diseases, Gingivitis, Semen analysis, Male infertility, Systematic review

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Background

Periodontal diseases represent one of the most common oral and dental problems worldwide, with a significant portion of the world population being affected by some form of periodontal condition [1]. The main cause of these conditions is deposition of microbial plaque on the teeth surface and gums. Poor oral hygiene exacerbates plaque buildup and proliferation of pathogenic bacteria, which triggering an inflammatory response and progressively destroys the tissues that support the teeth [2]. Diseases such as gingivitis and periodontitis can eventually lead to tooth loss and other serious oral health complications [3]. While these diseases originate in the mouth, evidence has indicated that the inflammation associated with periodontal disease can have far-reaching systemic effects [4]. In fact, a plethora of evidence underlines the interaction between periodontal disease and cardiovascular problems [5], diabetes [6], depression [7], and even preterm labor [8].

These findings form the background that has raised scientific interest in investigating the possible influence of periodontal diseases on the male reproductive system. Indeed, the hypothesis suggests that chronic inflammation caused by periodontitis might lead to a disturbance in reproductive activity by increasing the levels of inflammatory cytokines and enhancing oxidative stress [9]. Such inflammatory responses, well-known for their systemic effects, may have a harmful impact on spermatogenesis and sperm quality. Sperm quality is among the parameters considered critical in the evaluation of male fertility. Evaluation of sperm quality is usually done based on sperm count, motility, and morphology [10, 11].

Many studies have established that chronic inflammatory diseases, oxidative stress, bad nutrition, and unhealthy lifestyle habits contribute to the deterioration of sperm quality that might lead to male infertility [12, 13]. Since periodontal diseases also belong to the group of diseases characterized by higher levels of inflammatory cytokines and oxidative stress, it would be reasonable to hypothesize that these diseases could negatively influence sperm quality. Recent studies have only just begun to examine this potential association, and some of these investigations report that males with periodontal diseases exhibit reduced sperm count and motility and a higher incidence of morphological abnormalities in their sperm [14–17].

Although the evidence is still limited, this increasingly broad area of evidence offers a reasonably and logically related explanation for periodontal inflammation with male fertility. In view of the high prevalence of periodontal diseases and enormously alarming declining rates of male fertility, it is in the best interest of research to critically investigate the relationship between both conditions. While several studies have determined a correlation, the results from these studies are often conflicting in nature, thus begging a comprehensive systematic review. This study, therefore, tries to collate and critically appraise all available studies in this realm of research to shed light on the consequence that periodontal disease has on sperm quality.

Materials and methods

The study adhered to the guidelines outlined in the PRISMA-P (Preferred Reporting Items for Systematic Review and Meta-Analysis Protocols) statement [18]. The research was registered in the International Prospective Register of Systematic Reviews (PROSPERO) at the National Institute for Health Research (PROSPERO code: CRD420251005800).

Search strategy

A systematic and comprehensive search was conducted across multiple international databases, including PubMed, EMBASE, ProQuest, Scopus, Web of Science (WOS), and Google Scholar, covering publications up to September 09, 2024. Specifically, Google Scholar was utilized for accessing grey literature such as theses, dissertations, and technical reports which might have been missed by traditional databases. In instances where only abstracts of relevant studies were accessible, the corresponding authors were contacted to obtain full-text versions (Fig. 1).

To ensure a thorough identification of relevant literature, we employed Medical Subject Headings (MeSH) for keyword selection. The MeSH terms utilized included "Periodontal Diseases", "Periodontitis", "Gingivitis", "Pyorrhea Alveolaris", "Semen Analysis", "Sperm Count", "Sperm Motility", "sperm morphology", "Oligospermia", and "Teratozoospermia." The terms were combined using the Boolean operators "OR" and "AND" in a systematic way to refine the search and maximize the retrieval of relevant studies.

Further, the reference lists of all identified articles were carefully reviewed to identify any other relevant publications. The search strategy for databases is detailed in Supplementary file, Table 2. The exact search strategy used in the PubMed database is as follows:

(((Periodontal Diseases[Title/Abstract]) OR (Disease, Periodontal[Title/Abstract]) OR (Periodontal Disease[Title/Abstract]) OR (Parodontosis[Title/Abstract]) OR (Parodontoses[Title/Abstract]) OR (Pyorrhea Alveolaris[Title/Abstract]) OR (Periodontitis[Title/Abstract]) OR (Periodontitides[Title/Abstract]) OR (Pericementitis[Title/Abstract]) OR (Pericementitides[Title/Abstract]) OR (dental infection[Title/Abstract]) OR (caries[Title/Abstract]) OR (odontogenic infection[Title/Abstract]) OR (oral inflammatory load[Title/Abstract]) OR (gingivitis[Title/

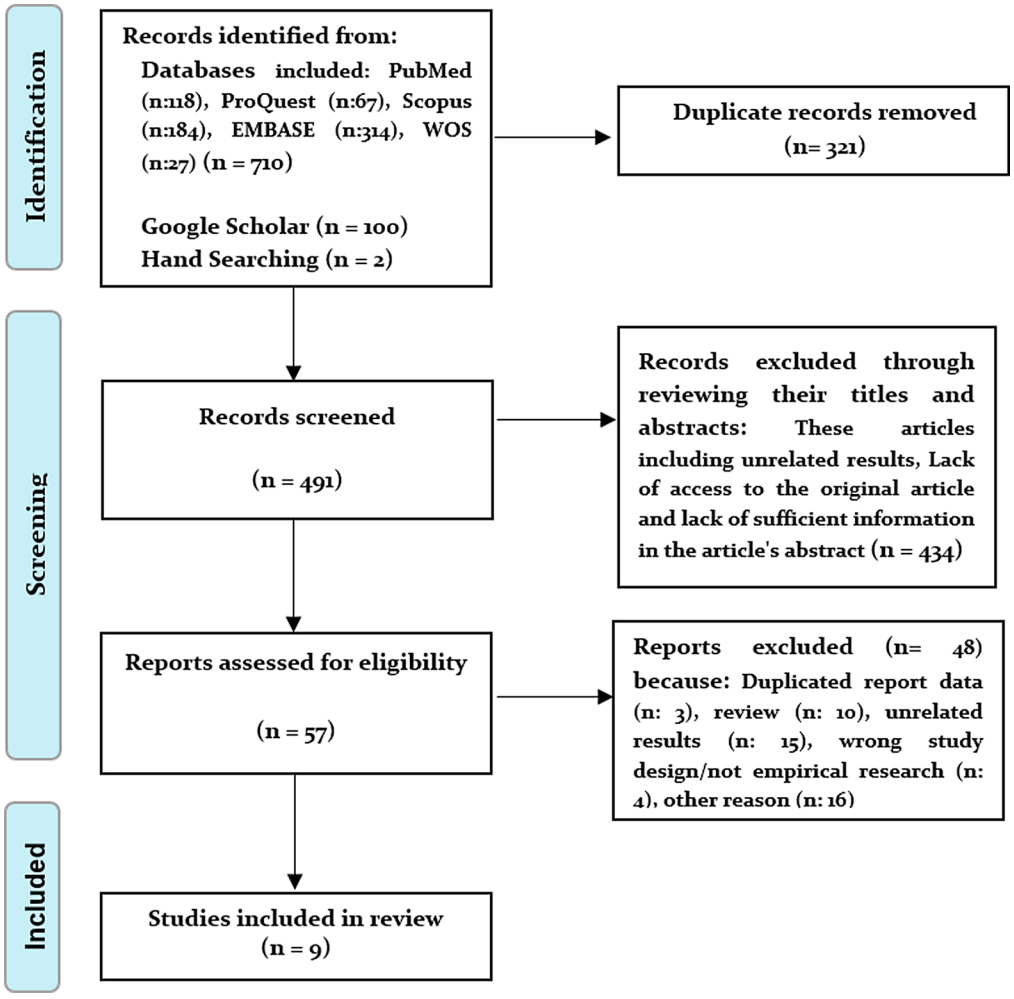

Fig. 1 Flowchart for selection of studies (PRISMA 2020)

Abstract]) OR (Gingival Index[Title/Abstract]) OR (Gingival Indic[Title/Abstract]) OR (Periodontal Indic[Title/Abstract]) OR (Periodontal Index[Title/Abstract]) OR (Community Periodontal Index of Treatment Needs[Title/Abstract]) OR (CPITN[Title/Abstract]) OR (Gingival Bleeding on Probing[Title/Abstract]) OR (Bleeding on Probing, Gingiva[Title/Abstract]) OR (Dental Health Survey[Title/Abstract]) OR (tooth loss[Title/Abstract]) OR (missing teeth[Title/Abstract]))) AND (((Semen Analysis[Title/Abstract]) OR (Semen Analyses[Title/Abstract]) OR (Semen Quality Analysis[Title/Abstract]) OR (Semen Quality Analyses[Title/Abstract]) OR (Semen Quality[Title/Abstract]) OR (Semen Qualities[Title/Abstract]) OR (Sperm Count[Title/Abstract]) OR (Sperm Number[Title/Abstract]) OR (Oligospermia[Title/Abstract]) OR (Oligoasthenoteratozoospermia[Title/Abstract]) OR (Oligozoospermia[Title/Abstract]) OR (Low Sperm Count[Title/Abstract]) OR (Hypospermatogenesis[Title/Abstract]) OR (Hypospermatogeneses[Title/Abstract]) OR (Cryptozoospermia[Title/Abstract]) OR (Cryptospermia[Title/Abstract]) OR (Sperm Motility[Title/Abstract]) OR (Sperm Motilities[Title/Abstract]) OR (semen parameters[Title/Abstract]) OR (sperm morphology[Title/Abstract]) OR (Asthenozoospermia[Title/Abstract]) OR (Astheno Teratozoospermia[Title/Abstract]) OR (Teratozoospermia[Title/Abstract]) OR (Asthenoteratozoospermia[Title/Abstract]) OR (Sperm Concentration[Title/Abstract]) OR (Sperm deformity[Title/Abstract]) OR (Semen volume[Title/Abstract]) OR (Semen pH[Title/Abstract]) OR (Sperm density[Title/Abstract]) OR (Sperm viability[Title/Abstract]) OR (Male Infertility[Title/Abstract]) OR (Male Subfertility[Title/Abstract]) OR (Male Sub-Fertility[Title/Abstract]) OR (Sperm[Title/Abstract]) OR (Semen[Title/Abstract])))

Eligible criteria

Inclusion criteria

We included case-control studies, cohort studies, and cross-sectional studies that investigated the relationship

between periodontal disease and sperm quality. Only peer-reviewed journal articles were considered. Studies had to involve adult men (≥ 18 years) diagnosed with periodontal disease, regardless of severity (gingivitis or periodontitis), and report sperm quality parameters such as sperm count, motility, morphology, and others. Eligible studies were required to explore the impact of periodontal disease (inflammatory or bacterial conditions related to the gums and surrounding structures) on semen parameters (sperm quality parameters, such as sperm count, motility, morphology, and others). Also, all relevant studies published up to the year 2000 were included in the study, with no language restrictions. For no- English language studies, if translation was not feasible, studies were included if sufficient data on the outcomes of interest were available in the abstract.

Exclusion criteria

Animal studies, in vitro experiments, or laboratory-based research that did not involve human subjects were excluded. Studies involving men undergoing treatments known to directly affect sperm quality (e.g., chemotherapy or hormone therapy) were excluded unless they specifically addressed periodontal disease as the primary exposure. Studies involving participants with systemic diseases (such as diabetes, cardiovascular disease, or other conditions that could confound the relationship between periodontal disease and sperm quality) were excluded unless adjustments for these variables were made. Studies that did not provide sufficient data on either periodontal disease or sperm quality or that lack full-text access were excluded.

Data collection

Study selection The Endnote X9 software was utilized to merge retrieved titles, eliminate duplicates, and screen titles and abstracts. Four investigators reviewed all potentially eligible citations to identify relevant studies. Two investigators (VM and NR) conducted a full-text review of selected citations to confirm study eligibility prior to data extraction. Discrepancies were resolved by consensus (VM, MB, MAK).

Data extraction

Data extraction was performed independently by two reviewers (VM and MAK) using a standardized data extraction form to ensure accuracy and consistency. Discrepancies between the two reviewers were resolved through discussion or consultation with a third reviewer (NR) if necessary. The following key data were extracted from each included study:

a) *Study Characteristics* (author's name, year of publication, country, type of study, and sample size).
b) *Population Characteristics* (participant demographics (e.g., age, and any relevant socioeconomic factors of participants), periodontal disease status (e.g., severity, classification such as gingivitis or periodontitis), information about any exclusion criteria used in the original study.
c) *Exposure (Periodontal Disease*): definition and diagnosis (e.g., clinical criteria, probing depth, gingival index, periodontal index), classification of the severity of periodontal disease, if available.
d) *Outcomes (Sperm Quality Parameters*): sperm count, sperm motility, sperm morphology (based on the World Health Organization (WHO) criteria), and other semen parameters such as sperm DNA fragmentation, and sperm concentration.
e) *Main Results*: The reported effects of periodontal disease on the different sperm quality parameters and their statistical significance.

Quality assessment

Two researchers (MB and VM) independently assessed the methodological quality of the included studies using the Newcastle-Ottawa Scale (NOS). The NOS evaluates studies across three domains: selection of study groups, comparability of groups, and ascertainment of exposure and outcomes, with a maximum score of 9 points [19]. Each study was scored based on these domains, with higher scores indicating better methodological quality. Discrepancies in scoring were resolved through discussion with a third author. The results of the quality assessment are presented in Table 1.

Data analysis

The extracted data were analyzed using descriptive statistics to summarize the findings across studies. For each included study, key characteristics were summarized, including study design, sample size, population demographics, periodontal disease severity, and sperm quality parameters. Summary tables were created to present these characteristics and outcomes. The findings from individual studies were qualitatively synthesized. The focus was on identifying patterns and trends in the relationship between periodontal disease and sperm quality. The synthesis highlighted common findings, discrepancies, and gaps in the literature.

Studies were compared based on their methodologies, populations, and results. This comparative analysis aimed to identify any significant differences or similarities in the reported effects of periodontal disease on sperm quality. The synthesized evidence was discussed in the context of the broader literature. Discussion focused on implications of findings, possible mechanisms that may link periodontal disease with sperm quality, and recommendations for future research.

Table 1 Overview of all included studies in this systematic review

ID	Authors, Year, Region	Sample characteristic	Age range/ average	Study design	Periodontal diagnostic method	Semen quality analysis	Outcomes					QS
							Sperm count	Sperm morphology	Sperm motility	Sperm concentration	Other	
1	Pourabbas et al., 2023, Iran [16]	229 men attending an infertility clinic	39.50 (28–56)	CS	Oral inflammatory load (OIL) by PD, BOP, CAL.	Seminogram (WHO 2010)	No significant relationship between oPMN counts and sperm count ($P=0.100$).	A relationship between oPMN counts and lower morphology ($P<0.001$).	A relationship between oPMN counts and reduced motility ($P<0.001$).	No significant relationship between oPMN counts and sperm concentration ($P=0.406$).	A relationship between oPMN counts and increased SDF ($P<0.001$).	8
2	Kheradmand et al., 2022a, Iran [20]	75 men with idiopathic infertility and periodontal infection	Not reported.	CS	Clinical periodontal examination	SCD method	-	-	-	-	A significant correlation between poor oral hygiene and fair or poor SDF. A relationship between periodontitis and increased SDF ($P<0.05$).	3
3	Tao et al., 2020, China [14]	192 men (129 With normospermia + 63 with pathospermia)	32 (29–35)	CC	BOP, PD, and CAL	Seminogram (WHO 2010)	No significant difference between periodontitis and sperm count ($P=0.169$).	-	lower median progressive motility ($P=0.008$) and total motility ($P=0.005$) among the men with more severe periodontitis.	No significant difference between periodontitis and sperm concentration ($P=0.335$).	A significantly higher proportion of the participants in the case group than that in the control group had moderate or severe periodontitis (33.3% vs. 17.8%, $p=0.012$)	7
4	Chidambar et al., 2019, India [21]	85 infertile men (64 with Periodontitis + 21 with only Gingivitis)	21–45	CS	PI, GI, BOP, PD, and CAL, recession	Seminogram (WHO 2010)	A significant relationship between periodontitis disease and lower count ($P<0.05$).	A significant relationship between periodontitis disease and lower morphology ($P<0.05$).	A significant relationship between periodontitis disease and reduced motility ($P<0.05$).	A significant relationship between periodontitis disease and sperm concentration ($P<0.05$).	-	5
5	Práger et al., 2017, Hungary [24]	199 men (106 with normospermia + 93 with any type of pathospermia)	Normospermia: 33.6; Pathospermia: 35.4	CC	BOP and PD	Seminogram (WHO 2010)	-	-	A relationship between history of gingival bleeding and more BOP with unsatisfactory sperm motility ($P<0.05$).	-	Poor periodontal status was found in about half of the study group (45.7%) (oligozoospermia, asthenozoospermia, cryptozoospermia, combined oligoasthenozoospermia).	7

Table 1 (continued)

ID	Authors, Year, Region	Sample characteristic	Age range/ average	Study design	Periodontal diagnostic method	Semen quality analysis	Outcomes					QS
							Sperm count	Sperm morphology	Sperm motility	Sperm concentration	Other	
6	Pásztor et al., 2016, Hungary [22]	95 men with idiopathic infertility	35.1 (23–51)	CS	PI, PD, BOP, missing teeth	Seminogram (WHO 2010)	No significant association between poor periodontal disease and sperm count ($p > 0.05$, NS). But 50.8% of the men with subnormal sperm count had poor periodontal status.	No significant association between poor periodontal disease and normal sperm morphology ($p > 0.05$, NS).	No significant association between poor periodontal disease and sperm motility (Progressive or non-Progressive motility) ($p > 0.05$, NS). lower BOP in asthenozoospermia group ($p = 0.046$).	No significant association between poor periodontal health and sperm concentration ($p > 0.05$, NS).	PD ≥ 4 mm more frequent in sperm abnormality group ($p > 0.05$, NS).	7
7	Nwhator et al., 2014, Africa (Nigeria) [17]	76 men (51 with subnormal spermatozoa + 25 with normal Spermatozoa)	25–56	CC	Oral hygiene status (OHIS) and CPITN probe	Seminogram (WHO 1999)	A significant association between poor oral hygiene/ periodontitis and subnormal sperm count ($p = 0.048$, $p = 0.026$).	-	-	-	-	8
8	Klinger et al., 2011, Israel [23]	75 men attending IVF clinic for sperm analysis	32.7	CS	Periodontal health assessment including: Number of missing teeth, PI, GI, PD, BOP, CAL	Seminogram (WHO 1999)	No significant association between periodontitis or gingivitis and sperm count ($p = 0.17$, NS).	-	CAL, PD & BOP was significantly associated with sperm sub-motility ($p < 0.05$).	-	-	7
9	Zhu et al., 2010, China [25]	360 (180 with normospermia + 180 with infertility)	Normospermia: 28.4 (24–39); Subfertile: 27.5 (22-46)	CC	PD, GI, CAL, ABL	Seminogram (WHO 1999)	-	A significant relationship between periodontitis disease and sperm deformity ($P < 0.05$).	Sperm live rate declined in subfertile men ($P < 0.05$).	A significant relationship between periodontitis disease and sperm concentration ($P < 0.05$).	Periodontitis prevalence of infertility and control group for 48.3%/31.7%, each difference was statistically significant ($P < 0.01$).	7

* CS: cross-sectional study; CC: case–control study; QS: Quality Score; SCD: Sperm Chromatin Dispersion; SDFi: Sperm DNA Fragmentation Index; oPMN: Oral polymorphonuclear neutrophil; BOP: bleeding on probing, PD: probing depth; CAL: clinical attachment loss; PI: Plaque Index; GI: Gingival Index; OHIS: Oral Hygiene Index Score; CPITN: Community periodontal index of treatment need; ABL: alveolar bone los

All results were narratively presented, but summary tables and figures were included wherever appropriate to help interpret the findings.

Results

Following PRISMA 2020 guidelines, 710 records were identified from databases (PubMed, ProQuest, Scopus, Embase, Web of Science), Google Scholar ($n = 100$), and hand searching ($n = 2$). After removing 321 duplicates, 491 records were screened, and 434 were excluded based on titles and abstracts. Of the 57 reports assessed for eligibility, 48 were excluded due to duplicated data, reviews, unrelated results, or inappropriate study design. Finally, 9 studies were included in the systematic review. A total of 9 studies were included in this review, comprising cross-sectional and case-control designs. Of these, 5 studies were cross-sectional designs [16, 20–23], while 4 studies were case-control studies [14, 17, 24, 25]. Most studies focused on populations of men attending infertility clinics, and comparisons were often made between men with periodontitis and those with healthy periodontal status.

The total sample size across all studies was 1,386 men, with sample sizes ranging from 75 to 360 participants. These studies were conducted across diverse geographical regions, such as Iran [16, 20], China [14, 25], India [21], Hungary [22, 24], Nigeria [17], and Israel [23].

The quality of the included studies was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies, focusing on three domains: selection, comparability, and outcome. Across the eight studies, the total NOS scores ranged from 3 to 8 out of a possible 9, indicating varying levels of quality. Four studies [14, 16, 17, 24] achieved high-quality scores (7 or 8), demonstrating strengths in representativeness of the sample, ascertainment of exposure, and comparability based on design or analysis. Conversely, Kheradmand et al. (2022a) [20] scored the lowest [3], primarily due to inadequate control for confounding factors and lack of statistical rigor in outcome assessment. The remaining studies [21–23, 25] scored between 5 and 7, with common limitations including non-representative samples and unclear ascertainment of exposure.

The assessment of periodontal disease also varied between studies but most often included measures such as Bleeding on Probing (BOP) [14, 16, 21–24], Probing Depth (PD) [14, 16, 21–25], Clinical Attachment Loss (CAL) [14, 16, 21, 23, 25], Plaque Index (PI) [21–23], and Gingival Index (GI) [21, 23, 25]. Sperm quality was assessed by semen analysis in a majority of studies that formed a part of this systematic review. The parameters used for the examination of the semen samples included sperm count, motility, morphology, and concentration. These parameters were interpreted in accordance with the WHO guidelines on semen analysis in order to maintain standardized criteria for defining normal and abnormal sperm parameters across all studies. In the study conducted by Kheradmand et al. 2022, however, the Sperm Chromatin Dispersion (SCD) method was used in particular for assessing Sperm DNA Fragmentation, a parameter not typically included in the WHO guidelines for semen analysis [20]. This enabled the researchers to look into DNA integrity a little more closely in relation to periodontal disease.

These studies have been conducted to explore the correlation of periodontitis with sperm quality parameters regarding sperm count, sperm motility, sperm morphology, and Sperm DNA Fragmentation (SDF). The findings from the overall studies indicated that periodontitis resulted in adverse effects on multiple aspects of sperm quality, with periodontitis prevalence being significantly higher in infertile men compared to healthy men [14, 24, 25].

Tao et al. (2020) reported that a significantly higher proportion of participants in the pathospermia group had moderate or severe periodontitis compared with the normospermia group (33.3% vs. 17.8%, $p = 0.012$ [14]. Práger et al. (2017) showed that poor periodontal status was found in about half of the study group, 45.7% (oligozoospermia, asthenozoospermia, cryptozoospermia, combined oligoasthenozoospermia) [24]. Zhu et al., 2010 demonstrated that chronic periodontitis prevalence was significantly higher in the infertile and control group with 48.3% and 31.7% respectively, $P < 0.01$ [25].

Association between periodontal disease and sperm count

Some studies showed that periodontal disease is associated with a reduction in sperm count, particularly in men with infertility. In the study done by Chidambar et al. (2019), periodontitis was found to be associated with a lower sperm count [21]. Nwhator et al. in 2014 also confirmed that men with poor oral hygiene or periodontitis exhibited oligozoospermia ($P = 0.048$) [17]. However, other studies found no significant association between periodontitis and sperm count, $P > 0.05$ [14, 16, 22, 23]. Pásztor et al., 2016, reported that poor periodontal status and sperm count were not significantly associated, $p > 0.05$, Not Significant (NS). However, 50.8% of men with subnormal sperm count had poor periodontal status [22].

Association between periodontal disease and sperm motility

Many studies reported that sperm motility was lower among men with periodontal diseases. Pourabbas et al. (2023) found that oral inflammatory load (OIL) was significantly associated with reduced sperm motility ($P < 0.001$, (CI: -0.819,-0.329)) [16]. Chidambar et al. (2019) observed a significant association between

periodontitis and reduced motility ($P = 0.03$) [21]. In the study conducted by Práger et al., in 2017, a history of gingival bleeding and higher Bleeding on Probing (BOP) were associated with unsatisfactory sperm motility [25]. Tao et al. presented similar results in 2020, reported lower median progressive motility (36.5% vs. 17.9%, $P = 0.008$) and total motility (36.2% vs. 18.6%, $P = 0.005$) among the men with more severe periodontitis [14]. According to Klinger et al. (2011), CAL, PD, and BOP were significantly associated with reduced sperm motility ($P < 0.05$) [23]. Zhu et al. (2010) also found the sperm live rate declined in subfertile men following a decrease in sperm motility [25]. However, Pásztor et al. (2016) reported no significant association between poor periodontal status and progressive or non-progressive motility ($p > 0.05$, NS) [22].

Association between periodontal disease and sperm morphology

The impact of periodontal disease on sperm morphology has been less studied, though some studies suggest that oral inflammation can lead to lower normal sperm morphology. Pourabbas et al. (2023) found that oral inflammatory load was associated with a decrease in the percentage of normal sperm morphology ($P < 0.001$, (CI: -0.463,-0.351)) [16]. Chidambar et al. (2019) also reported that the rate of abnormal sperm morphology was higher in men with chronic periodontitis [21]. Zhu et al. (2010) also found that sperm deformity increased with statistical significance in infertile men [25]. However, Pásztor et al., 2016 showed that no significant association between poor periodontal status and normal sperm morphology ($p > 0.05$, NS) [22].

Association between periodontal disease and other sperm parameters.

a) ***Sperm DNA Fragmentation (SDF)***: Two studies investigated the relationship between periodontal diseases and Sperm DNA Fragmentation. Both studies reported that periodontitis is associated with higher levels of DNA fragmentation in sperm. Pourabbas et al., 2023, demonstrated that oral inflammation was significantly associated with increased SDF ($P < 0.001$, (CI: 0.651,0.814)) [16]. Kheradmand et al., 2022, confirmed that periodontitis was related to higher levels of SDF, indicating an increased risk of DNA fragmentation [20].
b) ***Sperm Concentration***: Sperm concentration was also affected by periodontal disease in several studies. Chidambar et al., 2019 and Zhu et al., 2010 found a significant relationship between periodontitis disease and sperm concentration [25, 26]. However, several studies indicated no reduction in sperm concentration in men with poor periodontal health [14, 16, 22].

Discussion

The present review study was conducted on 1,386 men to evaluate the association between periodontal disease and sperm quality, examining parameters such as sperm count, motility, morphology, DNA fragmentation, and concentration. The findings suggest a significant association between periodontal disease and poor sperm quality in multiple aspects, though variations exist across studies.

Periodontal disease and sperm count

The results of this study indicate an association between periodontitis and reduced sperm count, indicating that inflammatory oral conditions might influence spermatogenesis. This aligns with findings of Kellesarian et al. (2018) [27], who reported a positive association between male factors infertility and dental health status. Lecaplain et al. (2021) [28] revealed a significant association between sex hormone levels, semen quality, and periodontitis.

Periodontitis is an inflammatory disease that affects the tooth-supporting tissues and eventually induces tooth loss. Periodontal inflammation induces the systemic release of pro-inflammatory cytokines (e.g., Interleukin 6, Interleukin 1 beta and tumor necrosis factor alpha) [29]. These cytokines can disrupt the hypothalamic-pituitary-gonadal (HPG) axis, ultimately resulting in impaired gonadotropin release, which is essential for testosterone production [30]. Reduced testosterone levels can compromise spermatogenesis, leading to decreased sperm count [31]. Additionally, chronic inflammation, through the release of these cytokines, can disrupt the blood-testis barrier (BTB), affecting the testicular environment and impairing sperm production [32]. These cytokines can reach the testes, weaken the tight junctions of Sertoli cells and increase BTB permeability, allowing immune cells to infiltrate the seminiferous tubules. This infiltration can damage developing sperm and impair fertility [33].

Periodontal disease and sperm motility

In our systematic review, numerous studies found that sperm motility was reduced in men with periodontal disease. This finding is consistent with reviews such as Kaltsas (2014), which found that inflammation-driven oxidative stress impairs sperm motility due to oxidative damage to sperm membranes [12]. The systemic increase in reactive oxygen species (ROS), resulting from periodontal disease, is a major contributor to reduced sperm motility. In periodontitis, oral pathogens trigger prolonged immune responses, which may elevate systemic

levels of ROS [34]. Although ROS is important in cellular signaling, its overproduction can damage sperm [35]. The cell membranes of spermatozoa have a very high content of polyunsaturated fatty acids, making them particularly susceptible to oxidative stress through lipid peroxidation [36, 37].

ROS can induce mitochondrial dysfunction in sperm, thereby affecting Adenosine triphosphate (ATP) generation, which is essential for flagellar motility [38]. ROS also disrupts axonemal structure at the sperm tail and impairs the machinery within the axoneme that is critical for motility. Excess ROS may also cause DNA damage, reducing sperm integrity and potential fertility [39]. Several studies have confirmed that in states of chronic inflammation, seminal fluid antioxidant enzymes such as superoxide dismutase and catalase are overwhelmed, further impairing sperm motility by contributing to oxidative stress [12, 40].

Periodontal disease and sperm morphology

Based on the results of this systematic review, some studies identified an association between poor oral health and abnormal sperm morphology, while others were inconclusive. Research has demonstrated that in semen samples contaminated with bacterial infections and leukocytospermia, altered sperm morphology is observed, often associated with nuclear abnormalities and compromised DNA integrity, particularly in the sperm head [41]. Abnormal morphology includes defects related to the development of the head, midpiece, or tail of the sperm, which decreases fertilizing capacity and affecting overall reproductive success [42]. Inflammation in periodontitis may also release prostaglandins and cytokines [43], which interfere with the cellular processes necessary for ensuring normal sperm morphology [16]. During spermatogenesis, inflammatory mediators can impair cytoskeletal structures, disrupting the shaping and maturation of spermatozoa [33].

Periodontal disease and other sperm parameters

This review also revealed a significant link between periodontitis and increased sperm DNA fragmentation, consistent with findings by Esteves et al. (2020) increased SDF levels have been implicated in male infertility and are associated with conditions such as varicocele, male accessory gland infection, advanced paternal age, cancer, chronic illness, exposure to environmental toxins, and lifestyle factors [44]. Sperm DNA fragmentation involves the impairment of DNA integrity through oxidative stress and inflammation originating from the sperm cell [45]. High levels of ROS and systemic inflammatory mediators, such as nitric oxide present in periodontitis, induce DNA strand breaks [46]. Such fragmentation can affect genetic material transported by the sperm, thereby interfering with normal embryonic development in the event of fertilization. This is particularly concerning for couple undergoing assisted reproductive technologies [47].

Based on the results of this systematic review, the studies examining sperm concentration showed mixed results, with some reporting a relationship with periodontitis and others finding no significant association. These findings are similar to the systematic review by Kellesarian et al. (2018), which noted inconsistent associations between inflammatory diseases and sperm concentration [27]. The cytokines secreted during chronic inflammation could suppress the HPG axis, inhibiting the Luteinizing Hormone (LH) and Follicle-Stimulating Hormone (FSH) levels, which are critical for stimulating the testes to produce sperm. Lower levels of LH and FSH can reduce spermatogenesis, leading to a decreased sperm concentration [48]. Moreover, the inflammatory mediators compromise the structural integrity of the BTB [32]. When cytokines weaken or break this barrier, toxins and immune cells can penetrate the testicular tissue, disrupting the highly regulated environment required for normal sperm production. This may lead to a reduced sperm concentration by directly impairing the process of spermatogenesis [9].

Strengths and limitations

A strength of our study is its comprehensive overview and focus on multiple sperm parameters. This review synthesized data from diverse regions and study designs, providing a broad perspective on how periodontal disease affects sperm quality. The integration of pathophysiological explanations offers a better understanding of the biological mechanisms linking periodontal health and sperm quality. Also, by examining various sperm quality indicators, this review highlights the multifaceted impact of periodontal disease on male reproductive health.

One of the key limitations of this review is the inability to perform a meta-analysis due to the significant heterogeneity observed across the included studies. This heterogeneity stemmed from variations in study designs, population characteristics, diagnostic criteria for periodontal disease, and methodologies used to assess sperm quality (e.g., differences in semen analysis protocols and outcome measures). Additionally, the limited number of studies ($n = 9$) and the potential risk of bias further precluded the feasibility of a meta-analysis, as it could have led to misleading conclusions or an oversimplification of the complex relationship between periodontal disease and sperm quality. As a result, we relied on a narrative synthesis to interpret the findings, which, while providing a nuanced understanding of the evidence, may limit the generalizability and statistical robustness of our conclusions. Future research should aim to standardize

methodologies and diagnostic criteria to facilitate more rigorous quantitative synthesis and strengthen the evidence base in this field. Another limitation is the small sample sizes in some studies, which may limit the generalizability of their findings. Most studies included were cross-sectional or case-control, which limits the ability to establish causality. Also, factors such as lifestyle, diet, and comorbidities (e.g., diabetes and smoking) could influence both periodontal and reproductive health, introducing potential confounding.

Clinical implications

The findings of this systematic review emphasize the importance of oral health, particularly periodontal disease, in addressing male infertility. In fact, chronic periodontal inflammation, through the release of pro-inflammatory cytokines and ROS, was found to adversely affect sperm quality parameters, including count, motility, morphology, and DNA integrity [39]. Given this, optimal oral health should be elevated to an integral part of the management of male infertility.

A close collaboration between dental practitioners and fertility experts is essential to ensure a comprehensive approach to addressing male infertility. Regular dental check-ups, early detection, and treatment of periodontal disease may improve sperm quality and fertilization outcomes [49]. Additionally, men with a history of infertility should be educated about the potential influence of oral health on reproductive health. Encouraging men to maintain good oral hygiene and seek timely treatment for periodontal conditions may serve as an adjunct therapy for improving fertility. Furthermore, addressing periodontal health in men with poor sperm quality could act as a preventive measure. As the link between periodontal disease and male fertility becomes more evident, periodontal care may prove to be a promising approach in fertility treatment protocols.

Conclusion

This systematic review provides robust evidence of an association between periodontal disease and reduced sperm quality across multiple parameters, suggesting that chronic oral inflammation may have systemic effects on reproductive health. Considering the identified pathophysiological mechanisms, maintaining optimal oral health may play a crucial role in improving sperm quality, particularly for men with infertility concerns. Future research should focus on large-scale, prospective studies to confirm these associations and clarify causative mechanisms.

Abbreviations

WOS	Web of Science
NOS	Newcastle-Ottawa Scale
PROSPERO	International Prospective Register of Systematic Reviews
WHO	World Health Organization
NS	Not Significant
OIL	Oral Inflammatory Load
HPG	Hypothalamic-Pituitary-Gonadal axis
BTB	Blood-Testis Barrier
ROS	Reactive Oxygen Species
SCD	Sperm Chromatin Dispersion
SDFi	Sperm DNA Fragmentation Index
oPMN	Oral polymorphonuclear neutrophil
BOP	Bleeding on probing
PD	Probing depth
CAL	Clinical attachment loss
PI	Plaque Index
GI	Gingival Index
OHIS	Oral Hygiene Index Score
CPITN	Community periodontal index of treatment need
ABL	Alveolar bone loss
ATP	Adenosine triphosphate
LH	Luteinizing Hormone
FSH	Follicle-Stimulating Hormone

Supplementary Information

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Supplementary Material 1

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Author contributions

Conceptualization: VM, MAK. Data collection: VM, MB. Methodology: NR, VM, MKA. Formal analysis: MB, NR. Writing – original draft: VM, NR, MB, MAK. Writing – review & editing: VM, NR, MB, MAK.

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Data availability

The data that support the findings of this study are available on request from the corresponding author (MAK).

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

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Competing interests

The authors declare no competing interests.

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