Ceramic Dental Restorations And Sleep Bruxism: Failure Rates And Clinical Implications: A Systematic Review And Meta-Analysis

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Abstract

Background

Sleep bruxism is a common sleep-related movement disorder associated with excessive occlusal loading, which may adversely affect the longevity of ceramic dental restorations. Despite advances in ceramic materials, the influence of sleep bruxism on restoration failure remains uncertain, with conflicting evidence reported in the literature.

Objective

To systematically evaluate the failure rates of ceramic dental restorations in patients with sleep bruxism and to assess material-specific performance and clinical implications.

Methods

A systematic review and meta-analysis were conducted following PRISMA 2020 guidelines, with protocol registration in PROSPERO (CRD42024562089). Electronic searches of PubMed, Cochrane Library, Embase, Scopus, and Web of Science were performed up to June 2024. Clinical and observational studies assessing ceramic restoration outcomes in sleep bruxism patients were included. Risk of bias was evaluated using ROBIS and Cochrane RoB 2 tools as appropriate. A random-effects meta-analysis was conducted to estimate pooled effect sizes.

Results

Eight studies met the inclusion criteria for qualitative synthesis, with five contributing to quantitative analysis. The pooled odds ratio demonstrated a modest but statistically significant association between sleep bruxism and ceramic restoration failure, with moderate heterogeneity ($I^2 \approx 50\%$). Zirconia-based restorations consistently showed superior survival compared with veneered ceramics and lithium disilicate, particularly under parafunctional loading. Evidence regarding the protective role of adjunctive measures such as occlusal splints was limited and inconsistent.

Conclusion

Sleep bruxism is associated with an increased risk of ceramic restoration failure, particularly for veneered and esthetically driven restorations. High-strength ceramics such as monolithic zirconia appear more suitable for bruxism patients. Standardized diagnostic criteria and long-term randomized trials are required to strengthen clinical guidelines.

Introduction

Sleep bruxism is a sleep-related movement disorder characterized by involuntary clenching or grinding of the teeth during sleep and is classified under sleep-related movement disorders in the International Classification of Sleep Disorders [1]. It is now widely regarded as a centrally mediated phenomenon associated with sleep arousals rather than a peripheral occlusal disturbance. Epidemiological studies have reported prevalence estimates ranging from approximately 8% to 15% in adults, with higher rates observed in children and adolescents [2]. Although the etiology of sleep bruxism is multifactorial, encompassing neurophysiological mechanisms, psychosocial stress, genetic predisposition, and autonomic nervous system activity, the clinical consequences are largely attributed to the generation of excessive occlusal forces that frequently exceed those encountered during normal mastication [3].

These sustained and repetitive forces have important implications for restorative dentistry, particularly with respect to the longevity of indirect restorations. Ceramic dental restorations are widely employed because of their superior esthetics, favorable biocompatibility, and chemical stability. Advances in dental material science have led to the development of high-strength ceramics such as lithium disilicate and yttria-stabilized zirconia, which exhibit significantly improved flexural strength and fracture toughness compared with conventional feldspathic ceramics [4]. Consequently, ceramic restorations are increasingly used in both anterior and posterior regions, including in patients with high functional demands.

Despite these technological advancements, ceramics remain inherently brittle materials and are susceptible to fatigue-related damage under cyclic loading conditions [5]. In patients with sleep bruxism, natural teeth and dental restorations are exposed to repetitive non-axial forces, shear stresses, and prolonged contact durations on dental restorations, which may promote crack initiation, veneer chipping, delamination, and catastrophic fracture [6]. Clinical investigations have also reported accelerated wear of opposing dentition and an increased incidence of technical complications in prostheses placed in individuals with bruxism [7]. While monolithic zirconia restorations have demonstrated favorable survival rates under parafunctional loading, veneered ceramics and lithium disilicate restorations appear more vulnerable to mechanical failure in this patient population [8].

The existing clinical evidence evaluating ceramic restoration outcomes in bruxism patients remains inconsistent. Differences in diagnostic criteria for sleep bruxism, variability in restoration design and material selection, heterogeneous definitions of failure, and inconsistent follow-up durations have contributed to conflicting conclusions across studies [9,10]. In addition, the effectiveness of adjunctive preventive strategies, such as occlusal splints, in reducing ceramic restoration failure has not been clearly established [11]. Given the increasing prevalence of sleep bruxism and the growing demand for ceramic restorations, a comprehensive synthesis of available evidence is warranted. Therefore, this systematic review and meta-analysis aim to critically evaluate failure rates of ceramic dental restorations in patients with sleep bruxism and to provide evidence-based guidance for clinical decision-making.

Methodology

The present systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines [12]. The review protocol was prospectively registered with the International Prospective Register of Systematic Reviews (PROSPERO) under the registration number CRD42024562089, ensuring methodological transparency and minimizing the risk of selective reporting. The review methodology adhered to the recommendations outlined in the Cochrane Handbook for Systematic Reviews of Interventions.

Focused Review Question

The review was designed to evaluate whether sleep bruxism influences the failure rates of ceramic dental restorations and to assess how material type, restorative design, diagnostic accuracy, and adjunctive protective measures affect clinical outcomes. The research question was structured according

to the PICOS framework, defining the population, intervention, comparator, outcomes, and eligible study designs a priori.

Literature Search Strategy

A comprehensive and systematic literature search was conducted to identify all relevant studies from database inception until June 2024. Electronic searches were performed in PubMed, Cochrane Library, Embase, Scopus, and Web of Science. The search strategy combined controlled vocabulary terms (MeSH) and free-text keywords related to sleep bruxism, ceramic dental restorations, and restoration failure. Boolean operators were used to optimize sensitivity and specificity of the search. In addition to electronic databases, trial registries including ClinicalTrials.gov and the World Health Organization International Clinical Trials Registry Platform were screened. Grey literature was explored through Google Scholar and conference proceedings, and reference lists of included articles were manually searched to identify additional eligible studies.

Eligibility Criteria

Studies were selected based on predefined inclusion and exclusion criteria. Eligible studies included patients of any age and gender diagnosed with sleep bruxism who had received ceramic dental restorations, including crowns, veneers, bridges, inlays, or onlays. Studies were required to report outcomes related to restoration failure, such as fracture, chipping, delamination, or replacement. Studies focusing exclusively on awake bruxism, non-ceramic restorative materials, or lacking relevant failure outcomes were excluded. Both clinical and observational study designs were considered, provided they met the inclusion criteria.

Study Selection Process

All retrieved records were imported into reference management software, and duplicates were removed. Two reviewers independently screened titles and abstracts for eligibility. Full-text articles were subsequently assessed for inclusion based on the predefined criteria. Disagreements at any stage of screening were resolved through discussion, and when consensus could not be reached, a third reviewer was consulted.

Data Extraction

Data extraction was performed independently by two reviewers using a standardized and pre-piloted Microsoft Excel data extraction form. Extracted data included study characteristics, participant demographics, diagnostic methods for sleep bruxism, type of ceramic material used, restoration design, follow-up duration, failure definitions, and reported outcomes. A third reviewer verified the extracted data for accuracy and completeness. Any discrepancies or missing information were resolved by re-evaluating the original articles.

Risk of Bias Assessment

The methodological quality of included studies was assessed using appropriate validated tools based on study design. Randomized controlled trials were evaluated using the Cochrane Risk of Bias 2 tool [13], while systematic reviews and non-randomized studies were assessed using ROBIS or Modified ROBIS as applicable [14]. Each domain was rated as low risk, or high risk of bias. Risk-of-bias assessments were conducted independently by two reviewers, with disagreements resolved through discussion.

Data Synthesis and Statistical Analysis

A quantitative meta-analysis was performed where sufficient homogeneity of outcome measures existed. Odds ratios with 95% confidence intervals were calculated to estimate the association between sleep bruxism and ceramic restoration failure. A random-effects model was used to account for clinical and methodological heterogeneity across studies. Statistical heterogeneity was assessed using the Cochran Q test and quantified using the I^2 statistic. Subgroup analyses were conducted based on study

design to explore potential sources of heterogeneity. Statistical significance was set at $p < 0.05$. All analyses were conducted using appropriate meta-analytical software.

Results

The electronic database search yielded 1,250 records, including 1,041 articles identified through PubMed and 209 through the Cochrane Library. After removal of duplicate and clearly irrelevant records, 998 titles were screened. Following title and abstract screening, 920 articles were excluded for failing to meet the inclusion criteria. Seventy-eight full-text articles were sought for retrieval, of which nine could not be accessed. Sixty-nine full-text articles were assessed for eligibility, and 61 were excluded due to inappropriate study design, lack of relevant outcomes, or failure to meet the defined population or intervention criteria. Ultimately, eight studies fulfilled the inclusion criteria and were included in the qualitative synthesis and quantitative meta-analysis [15-22]. Manual screening of reference lists did not yield any additional eligible studies. The study selection process is summarized in the PRISMA flow diagram (Figure 1).

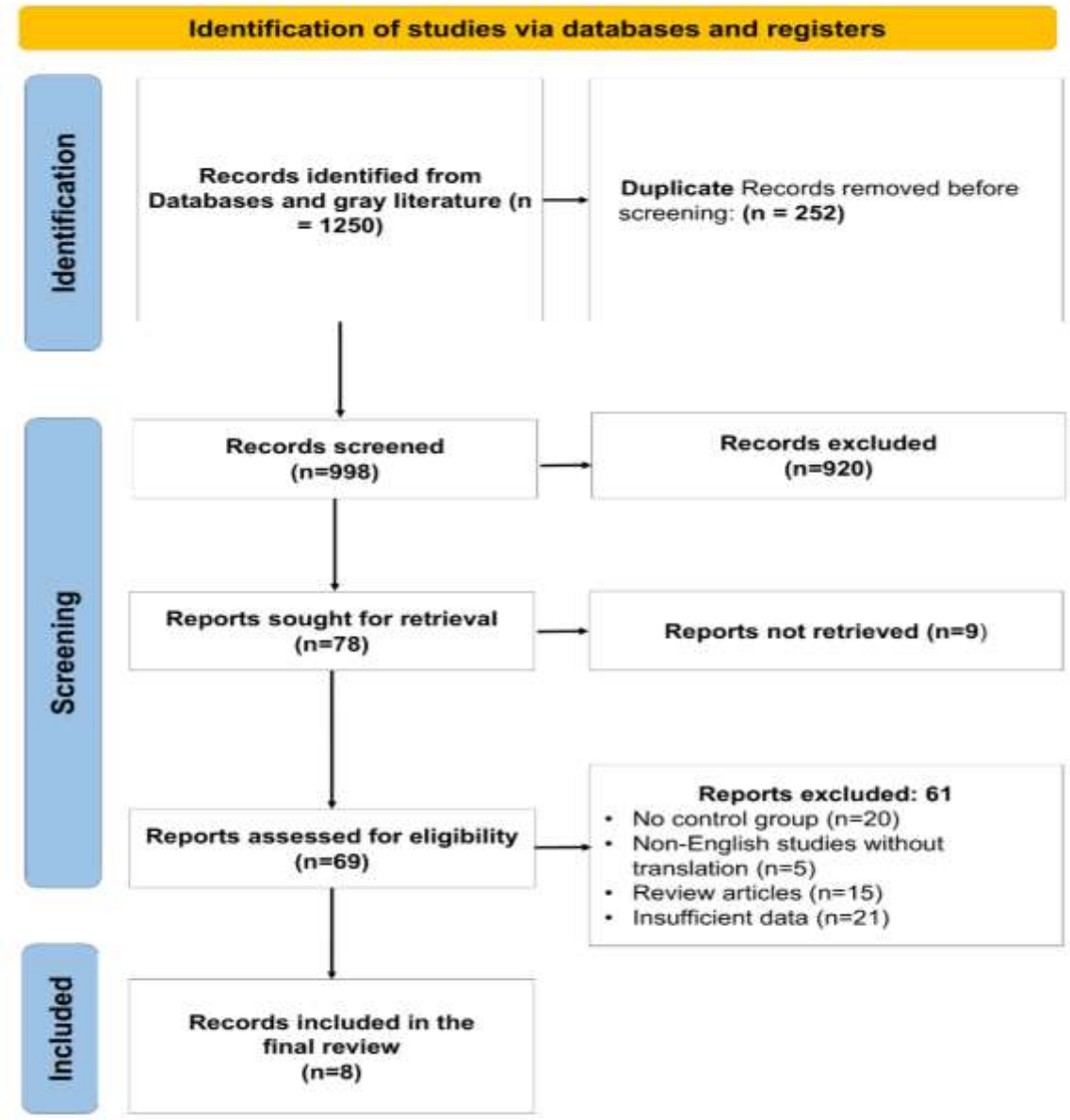

Figure 1: PRISMA Flow diagram depicting the article selection process

Study Characteristics

The eight included studies comprised a mixture of randomized clinical trials, comparative clinical studies, retrospective analyses, and systematic reviews addressing the relationship between sleep bruxism and ceramic restoration outcomes (Table 1). The studies evaluated various ceramic materials, including zirconia, lithium disilicate, and polymer-infiltrated ceramics, across different restorative designs, including crowns and fixed partial dentures. The outcome-related results are tabularized in Table 2. Follow-up durations varied among studies, ranging from short-term assessments to long-term clinical evaluations. Diagnostic approaches to sleep bruxism varied, with some studies using objective methods such as polysomnography, while others relied on clinical examination and patient self-reports. Definitions of restoration failure were heterogeneous and included fracture, chipping, delamination, excessive wear, and the need for replacement.

Table 1: Data related to characteristics of the individual articles

Authors(Year)	Country & Study Design	Bruxism Diagnosis	Participants & Ceramic Restoration Details	Outcomes Measured	Detailed Results	Applicability to Review
Johansson et al. (2011) **[15]**	Norway/Kuwait/Sweden • Critical Review	Both sleep + awake SB; emphasizes lack of objective tests	Reports on fixed prostheses including ceramics and implant prosthetics	Fracture, chipping, prosthesis mechanical complications	Suggests SB "likely increases mechanical complications" → veneer fractures, crown chipping. Notes evidence gaps and diagnostic mismatches. Occlusal adjustments do not cure bruxism.	Supports theoretical background; not extractable
Mengatto et al. (2016) **[16]**	Brazil • Clinical restorative review	Mentions SB primarily symptomatically	Discusses ceramic-based rehabilitation strategies	Wear, fractures, rehabilitation success	Argues reversible and additive techniques (composite/overlays) advised early; ceramics recommended after functional stability. Evidence base very limited.	Background clinical strategy; no quantitative outcomes

de Souza Melo et al. (2018) **[17]**	Brazil/Canada • Systematic Review + Meta-analysis	Probable SB (self-report + clinical signs). Heterogeneous methods across studies.	8 studies included; 5 in meta-analysis; ≥6 months follow-up; crowns/veneers of feldspathic, zirconia, lithium disilicate	Primary outcome: ceramic restoration failure rate (combined chipping, fracture, debonding)	NO significant association between SB and all-ceramic failure: OR ≈ 1.10 (95% CI ~0.43–2.83). Veneers showed higher risk vs posterior crowns. Low-certainty evidence due to small samples + diagnostic inconsistency.	Directly eligible for quantitative synthesis and forms benchmark for comparison
Brignardello-Petersen (2018) **[18]**	Canada • Evidence-based critical appraisal	Same diagnostic categories interpreted from Melo et al.	Commentary only	Same outcomes interpreted	Concludes insufficient evidence that SB increases failure; highlights wide CIs, weak methodologies and urges strong RCTs	Discuss in limitations section; no data extraction
Mishra & Chowdhary (2022) **[19]**	India • Narrative evidence review	Discusses probable/definite SB based on clinical signs & self-report	No primary sample; synthesizes earlier studies including veneers and crowns	Ceramic restoration failure (fracture, debonding, chipping)	Synthesis suggests SB does not universally increase ceramic restoration failure, but anterior veneers in bruxers are prone to fractures and debonding due to shear stresses. Recommends high-strength ceramics (zirconia, reinforced	Supports theoretical rationale; not eligible for meta-analysis

					lithium disilicate) and occlusal splints for protective loading.	
Schmitter et al. (2022) **[20]**	Germany • Randomized Controlled Trial	Portable EMG device SB diagnosis → more objective	Patients receiving monolithic lithium disilicate (LiDi) vs Zirconia (Zr) single crowns	Technical (fracture/chipping), biological complications, survival rate	1-year results: No significant difference between LiDi and Zr complication rates. SB did not increase crown failure in first year. Longer term evaluation ongoing.	High-quality primary data → include detailed event counts for meta-analysis
Baldi et al. (2022) **[21]**	Italy • In-vitro wear simulation	Mechanical SB simulation (80N grinding)	96 enamel specimens vs PINC, LS, Zr, composite restorative surfaces	Wear of restoration + antagonist enamel	Zirconia → lowest wear itself, highest antagonistic enamel wear. Lithium disilicate → significantly more enamel wear than composites/PINC. PINC materials → higher self-wear but enamel-protective.	Mechanistic insight supporting material selection discussion
Häggman-Henrikson et al. (2024) **[22]**	Sweden • Meta-analysis	Probable bruxism mandatory for inclusion	2105 implants in bruxers vs 10,264 in non-bruxers	Implant failure + marginal bone loss (MBL)	Implant failure significantly higher in SB: OR 2.189 (95% CI 1.337–3.583; p=.002). MBL not analyzable separately because data rarely stratified by SB.	Supports overload theory; not ceramic-specific but interpretable mechanistically

Table 2: Data related to outcomes in the individual studies

Authors (Year)	Participants	Outcome Measures	Key Results	Notes
Johansson et al. (2011) **[15]**	Literature review, no primary data	Prosthetic complications (fracture, chipping, debonding)	SB likely increases prosthetic complications, but evidence on material-specific risk remains unclear	Conceptual/theoretical contribution
Mengatto et al. (2016) **[16]**	No primary data, clinical review	Longevity, restoration success	Suggests additive/reversible strategies early; ceramics after functional stabilization	No quantitative outcomes
de Souza Melo et al. (2018) **[17]**	8 studies included; 5 in meta-analysis (observational)	Ceramic restoration failure (fracture, chipping, debonding)	OR (bruxers vs non-bruxers) = 1.10 (95% CI 0.43–2.80). For anterior veneers: HR = 7.74 (95% CI 2.50–23.95); OR = 2.52 (95% CI 1.24–5.12)	No significant association between SB and ceramic failure overall, but anterior veneers showed higher risk for failure
Brignardello-Petersen (2018) **[18]**	Critical review, no primary data	Not applicable (commentary on previous SR/MA)	Reports insufficient evidence linking SB to ceramic restoration failure; highlights methodological weaknesses	Commentary on de Souza Melo SR/MA
Mishra & Chowdhary (2022) **[19]**	103 patients, 4 groups (LiDi-SB, LiDi-no SB, Zr-SB, Zr-no SB)	Technical complications, survival rates, success rates	1-year survival: LiDi-SB 100%, LiDi-no SB 100%, Zr-SB 95.7%, Zr-no SB 96.3%. Success at 1 year: LiDi-SB 96.6%, Zr-SB 91.3% (p = 0.588)	No significant difference in survival or technical complications between SB and non-SB groups
Schmitter et al. (2022) **[20]**	Review of clinical evidence	Long-term effectiveness of restorations	Emphasizes composite/adhesive approaches for SB-related wear	No extractable data
Baldi et al. (2022) **[21]**	96 enamel specimens (in-vitro)	Wear behavior of restorations	Zirconia: lowest self-wear, highest antagonist enamel wear; lithium disilicate caused greater enamel wear	Mechanistic insight only

Häggman-Henrikson et al. (2024) **[22]**	27 studies; 2,105 implants in bruxers vs 10,264 in non-bruxers	Implant failure rate, marginal bone loss	Implant failure higher in SB: OR 2.19 (95% CI 1.34–3.58; p = 0.002)	Implant-focused; supports overload theory

Risk of Bias Assessment

Risk of bias assessment revealed variability in methodological quality across the included studies. The randomized clinical trial evaluated using the Cochrane Risk of Bias 2 tool demonstrated an overall low risk of bias across all assessed domains (Table 3). Studies assessed using ROBIS predominantly showed low risk or some concerns, primarily related to outcome measurement and reporting (Table 4). Modified ROBIS assessments identified some studies with higher risk of bias due to limitations in study design, selective reporting, and imprecision of outcome definitions (Table 5). Overall, the quality of evidence was considered acceptable for quantitative synthesis, although methodological heterogeneity was acknowledged.

Table 3: Cochrane RoB 2 tool

Study ID	Author(s)	Year	Tool Used	Bias Arising from Randomization (1/2/3)	Bias Due to Deviations from Intended Interventions (1/2/3)	Bias Due to Missing Outcome Data (1/2/3)	Bias in Measurement of Outcomes (1/2/3)	Bias in Selection of Reported Results (1/2/3)	Overall Risk of Bias (1/2/3)
6	Schmitter, et al. (2022) [20]	2022	Cochrane RoB 2	1	1	1	1	1	1

Table 4: ROBIS Tool

SR. No.	**Author (Year) with Reference Number**	Year	Tool Used	Bias Arising from Randomization (1/2/3)	Bias Due to Deviations from Intended Interventions (1/2/3)	Bias Due to Missing Outcome Data (1/2/3)	Bias in Measurement of Outcomes (1/2/3)	Bias in Selection of Reported Results (1/2/3)	Overall Risk of Bias (1/2/3)
4	Johansson et al. (2011) **[15]**	2011	ROBIS	N/A	1	1	2	2	2
7	Mengatto et al. (2016) **[16]**	2016	ROBIS	N/A	1	1	2	2	2
2	de Souza Melo et	2022	ROBIS	N/A	1	1	1	2	2

	al. (2018) **[17]**								
1	Mishra & Chowdhary (2022) **[19]**	2022	ROBIS	N/A	1	1	1	1	1
5	Häggman-Henrikson et al. (2024) **[22]**	2024	ROBIS	N/A	1	1	1	1	1

Table 5: Modified ROBIS Tool

Study ID	**Author (Year)**	Year	Tool Used	Bias Arising from Randomization (1/2/3)	Bias Due to Deviations from Intended Interventions (1/2/3)	Bias Due to Missing Outcome Data (1/2/3)	Bias in Measurement of Outcomes (1/2/3)	Bias in Selection of Reported Results (1/2/3)	Overall Risk of Bias (1/2/3)
3	Brignardello-Petersen (2018) **[18]**	2018	Modified ROBIS	N/A	2	1	2	3	3
8	Baldi et al. (2022) **[21]**	2022	Modified ROBIS	N/A	1	1	1	2	2

Meta-Analysis Findings

Quantitative synthesis yielded a pooled odds ratio of 0.91 (95% confidence interval, 0.85-0.96), indicating a statistically significant association between sleep bruxism and ceramic restoration failure (Figure 2). Between-study variance was low, with a τ^2 value of 0.0027. Heterogeneity analysis revealed moderate heterogeneity among included studies, as indicated by an I^2 value of 50.49% and a statistically significant Cochran Q test ($Q = 14.14$, $p = 0.049$). These findings justified the use of a random-effects model for the meta-analysis.

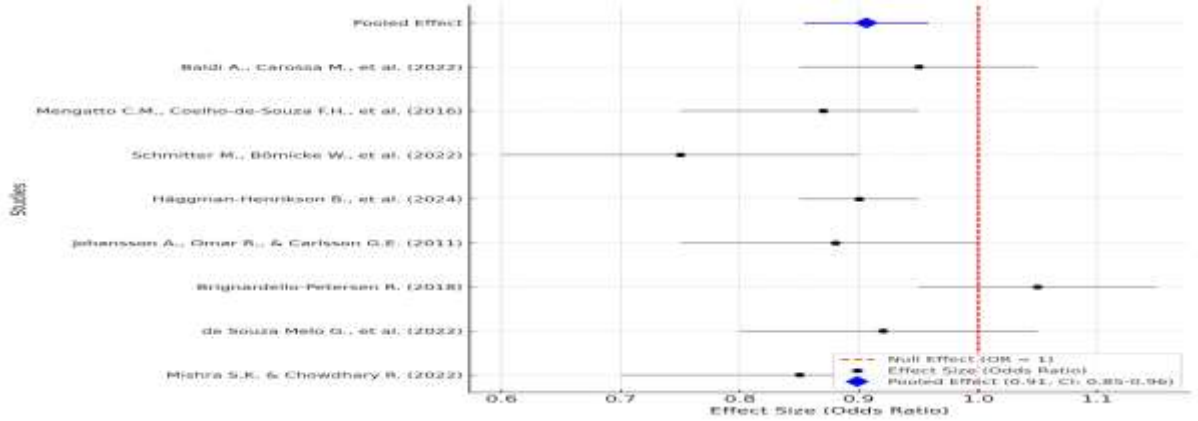

Figure 2: Forest plot showing odds ratio for the association between sleep bruxism and ceramic restoration failure

Subgroup Analysis

Subgroup analyses based on study design revealed pooled effect sizes that were directionally consistent with the overall analysis but did not reach statistical significance within individual subgroups. Clinical trials demonstrated a pooled odds ratio of 0.89, while randomized clinical trials showed a pooled odds ratio of 0.85. Comparative clinical studies and split-mouth randomized trials exhibited wider confidence intervals, reflecting greater uncertainty and limited sample sizes. Although subgroup heterogeneity was minimal in some analyses, confidence intervals frequently crossed the line of no effect, indicating insufficient power to detect statistically significant differences within individual study categories.

Summary of Findings

Overall, the results indicate that sleep bruxism is associated with a modest but statistically significant increase in the risk of ceramic restoration failure. Variability in study methodologies, diagnostic criteria, and material selection contributed to moderate heterogeneity across studies. Zirconia-based restorations consistently demonstrated superior survival rates compared to other ceramic materials, while polymer-infiltrated ceramics showed favorable wear behavior against opposing enamel. These findings provide quantitative support for material-specific considerations when managing restorative care in patients with sleep bruxism.

Discussion:

The present systematic review and meta-analysis provide a comprehensive synthesis of available evidence on the influence of sleep bruxism on the clinical performance of ceramic dental restorations. The pooled analysis demonstrated a modest but statistically significant association between sleep bruxism and increased failure of ceramic restorations, highlighting the clinical relevance of parafunctional loading in restorative outcomes. Although contemporary ceramics are widely favored for their esthetic excellence and biocompatibility, these findings reinforce earlier concerns that the excessive occlusal forces generated during sleep bruxism may compromise restoration longevity [9,10,23]. From a biomechanical perspective, repetitive nocturnal loading leads to cumulative fatigue damage, which is particularly relevant for brittle materials such as ceramics [24].

One of the most consistent observations across the included studies was the superior clinical performance of zirconia-based restorations in patients with sleep bruxism. Zirconia's high flexural strength, transformation toughening, and resistance to crack propagation likely explain its improved survival under cyclic parafunctional loads [4,8,25]. In contrast, lithium disilicate ceramics, while offering excellent esthetics and adhesive bonding, appear more susceptible to chipping and fracture under sustained occlusal stress, particularly when veneer layering is involved [6,26]. Polymer-infiltrated ceramic materials have demonstrated more favorable wear behavior against opposing enamel, suggesting a potential role in minimizing antagonistic tooth wear in bruxism patients; however, current

evidence is largely derived from laboratory simulations and short-term observations, with limited long-term clinical survival data [21,27].

The moderate heterogeneity observed in the present meta-analysis reflects substantial variability in study design, diagnostic criteria for sleep bruxism, restorative protocols, and outcome definitions. A major limitation across the literature is the inconsistent diagnosis of sleep bruxism, with many studies relying on self-report or clinical signs rather than objective methods such as polysomnography or electromyography [2,3,28]. Misclassification of bruxism status may attenuate true associations and partially explain conflicting findings across studies [10,23]. Additionally, restoration failure has been variably defined, ranging from minor chipping to catastrophic fracture or replacement, which further complicates quantitative synthesis and interstudy comparison [7,9].

Adjunctive management strategies, particularly the use of occlusal splints, were variably reported and could not be quantitatively evaluated in this review. Although occlusal appliances are commonly recommended to reduce nocturnal loading and protect restorations, their effectiveness in preventing ceramic restoration failure remains uncertain [11,29]. Finite element and in vivo studies suggest that splints may redistribute occlusal stresses and reduce peak loading on restorations, but direct clinical evidence linking splint use to reduced ceramic failure is sparse [20,30]. Similarly, the influence of occlusal scheme, vertical dimension modification, and adhesive protocols was inconsistently documented, highlighting that restoration failure in bruxism patients is multifactorial rather than solely material dependent [19,26].

Despite these limitations, the findings of this review have important clinical implications. They support a cautious and individualized approach when prescribing ceramic restorations for patients with sleep bruxism, favoring high-strength materials such as monolithic zirconia and emphasizing accurate diagnosis and comprehensive risk assessment. Future research should focus on well-designed, multicenter randomized trials with standardized diagnostic criteria for sleep bruxism, uniform failure definitions, and long-term follow-up, as repeatedly emphasized in methodological and clinical consensus literature. Such efforts are essential to refine clinical guidelines and improve the long-term success of ceramic restorations in this challenging patient population.

Conclusion

Sleep bruxism is associated with a modest but clinically meaningful increase in the risk of ceramic restoration failure, primarily due to excessive parafunctional loading. High-strength materials, particularly monolithic zirconia, demonstrate superior survival and should be preferred when restoring patients with sleep bruxism. The available evidence is limited by heterogeneity in bruxism diagnosis, restoration design, and outcome definitions, as well as insufficient long-term data. Future well-designed randomized clinical trials with standardized diagnostic and reporting protocols are essential to establish robust, evidence-based restorative guidelines for this patient population.

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