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SYSTEMATIC REVIEW

Association of sleep bruxism with ceramic restoration failure: A systematic review and meta-analysis

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ABSTRACT

Statement of problem. Ceramic restorations are popular because of their excellent optical properties. However, failures are still a major concern, and dentists are confronted with the following question: is sleep bruxism (SB) associated with an increased frequency of ceramic restoration failures?

Purpose. The purpose of this systematic review and meta-analysis was to assess whether the presence of SB is associated with increased ceramic restoration failure.

Material and methods. Observational studies and clinical trials that evaluated the short- and long-term survival rate of ceramic restorations in SB participants were selected. Sleep bruxism diagnostic criteria must have included at least 1 of the following: questionnaire, clinical evaluation, or polysomnography. Seven databases, in addition to 3 nonpeer-reviewed literature databases, were searched. The risk of bias was assessed by using the meta-analysis of statistics assessment and review instrument (MAStARI) checklist.

Results. Eight studies were included for qualitative synthesis, but only 5 for the meta-analysis. Three studies were categorized as moderate risk and 5 as high risk of bias. Clinical and methodological heterogeneity across studies were considered high. Increased hazard ratio (HR=7.74; 95% confidence interval [CI]=2.50 to 23.95) and odds ratio (OR=2.52; 95% CI=1.24 to 5.12) were observed considering only anterior ceramic veneers. Nevertheless, limited data from the meta-analysis and from the restricted number of included studies suggested that differences in the overall odds of failure concerning SB and other types of ceramic restorations did not favor or disfavor any association (OR=1.10; 95% CI=0.43 to 2.8). The overall quality of evidence was considered very low according to the GRADE criteria.

Conclusions. Within the limitations of this systematic review, the overall result from the meta-analysis did not favor any association between SB and increased odds of failure for ceramic restorations. (J Prosthet Dent 2018;119:354-62)

The increasing demand for esthetic procedures has led to the development of esthetic restorative materials that can withstand occlusal forces. Dental ceramics composed predominantly of glass particles lack adequate fracture resistance for posterior applications, unless combined with metal frameworks.[1] However, metal exposure in the cervical area can affect the esthetics of the prosthesis. Therefore, high-strength crystalline ceramic restorations have become popular.[2,3]

Initially, high-strength ceramics were veneered with feldspathic porcelain[4]; however, chipping of the veneering porcelain has been reported.[5-9] Subsequently, restorations fabricated from a single reinforced ceramic block have gained popularity. These may have

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Clinical Implications

Ceramic restoration failures are an undesired outcome. Limited evidence regarding a possible association with sleep bruxism suggested that the complex relation between occlusal overload and the occurrence of restoration failures is still unclear. Therefore, clinicians should use caution when planning prostheses for individuals with the diagnosis of sleep bruxism.

better properties because of the absence of multiple layers with different physical behaviors under thermal expansion.[3]

In spite of the improvement in the mechanical properties of ceramic restorations, fracture is still reported as the most common failure,[10] and layered restorations are more likely to be involved.[3,8] In addition, bruxism or occlusal hypervigilance, which is characterized as an amplification of aversive sensations and which may increase the activity of the masticatory muscles, are often reported to be poorly observed.[11] These characteristics may be associated with restoration failures because occlusal overload may generate abnormal mechanical stress.[11,12]

According to the American Academy of Sleep Medicine, sleep bruxism (SB) is defined as repetitive jaw-muscle activity characterized by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible during sleep.[13] In addition, other signs and symptoms of SB may include tooth wear, tongue and cheek indentations, jaw locking, muscle hypertrophy morning headaches, muscle pain, and fatigue.[14] The reference standard for diagnosing SB has been the polysomnography (PSG) examination, but its cost and patient accessibility limits its use.[15] Alternatively, a questionnaire-based evaluation associated with a clinical examination is often more suitable for large samples.[16] Moreover, SB prevalence is reported to be approximately 8% of the general adult population.[17,18]

Many ceramic systems have been marketed without proof of long-term clinical performance,[19] and, although some studies have demonstrated that ceramic restorations have clinically adequate mechanical properties, the role SB plays in individuals with ceramic restorations is still unclear.[12] Therefore, the purpose of this systematic review was to answer the following focused question: "Is sleep bruxism associated with an increased frequency of ceramic restoration failures?"

MATERIAL AND METHODS

This systematic review was developed by following the Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) checklist.[20] The study protocol was registered at the Prospective Register of Systematic Reviews (PROSPERO; Centre for Reviews and Dissemination, University of York; and the National Institute for Health Research) under the registry number CRD4201604847.[21]

Clinical trials or observational studies that investigated the short- and long-term evaluation of ceramic restorations in SB participants and studies that evaluated fixed ceramic dental prostheses were included in this review. A minimum follow-up time of 1 year after permanent cementation was considered short term, while a minimum mean follow-up time of 5 years was considered long term. No publication time, age, or sex restrictions were applied, and only publications in the Roman alphabet were accepted. Fractures, cracks, chippings, debonding from the tooth, and delamination of the veneering porcelain of the framework were considered restoration failures as well as biological complications such as secondary caries and irreversible pulpitis. Sleep bruxism must have been diagnosed by at least 1 of the following criteria: questionnaires, clinical evaluation, or polysomnography.

The 7 exclusion criteria were as follows: studies in which samples included individuals with craniofacial anomalies, genetic syndromes, or neuromuscular diseases; studies in which the sample included children (younger than 13 years of age); studies that evaluated the survival rate of removable or implant-supported prostheses, as well as metal-ceramic, composite resin, and ceramic-optimized polymer (ceromer) restorations; studies that had less than 1 year of follow-up time; studies in which SB had no or unclear diagnostic criteria (even after trying to contact the authors); studies that had missing information, no bruxism experimental group, or a different objective; and reviews, case reports, protocols, personal opinions, letters, posters, conference abstracts, or laboratory research.

Appropriate word combinations and truncations were developed for each of the following bibliographic databases: Embase, Latin American and Caribbean Health Sciences (LILACS), LIVIVO, PubMed (including Medline), Science Direct, the Cochrane Library, and Web of Science. A nonpeer-reviewed literature search was also performed on Google Scholar, OpenGrey, and ProQuest Dissertations, and Theses Global (Supplemental Table 1). Additional manuscripts were manually searched by checking the list of references of the included studies and by email contact with experts. The references were managed using software (EndNote X7; Thomson Reuters). All database searches were conducted from the starting coverage date through September 25, 2016.

A 2-phase process was followed to select studies. In phase 1, titles and abstracts of identified records were

Table 1. Summary of descriptive characteristics of included articles (n=8)

Study, Year; Country (Group)	Sample Size, n/female (%)	Case/Control, n (%)	Age (y) Range, mean ±SD	Follow-up Time (mo)	SB Diagnostic Methods/ Grading System (Lobbezoo et al[10]; 2013)
Beier et al,[27] 2012; Austria (laminate veneers)	84 participants /46 women (55% of the sample) 318 teeth	**Bruxism** 42 (50%) **Control** 42 (50%)	44.42 ±13.14	118 ±63	Self-report; Clinical inspection (signs of clenching or grinding)
Beier et al,[25] 2012; Austria (inlays, onlays, laminate veneers, single-crowns)	302 participants /182 women (60% of the sample) 1335 teeth	**Bruxism** 106 (35.1%) Occlusal guard (n=not reported) **Control** 196 (64,9%)	46.51 ±13.14	102 ±60	Self-report; Clinical inspection (signs of occlusal wear)
Beier et al,[26] 2012; Austria (inlays and onlays)	120 participants /74 women (61,7% of the sample) 587 teeth	**Bruxism** 40 (33%) Occlusal guard (n=not reported) **Control** 80 (67%)	46.2 ±12.5	111 ±63	Means of direct questions and visual observation of participant behavior and teeth (presence of facets by clenching, grinding, and gnashing)
Fabbri et al,[28] 2014; Italy (onlays, single-crowns, veneers)	312 participants /169 women (54.2%) 808 teeth	**Bruxism** 52[b] (16.6%) **Control** 260 (83.4%)	**Men** 19-61 **Woman** 19-71	12-72	Questionnaire (muscle or teeth tenderness in morning or evening, morning headache; reported sounds of teeth grinding from partner; diurnal feeling of teeth clenching, and frequent fractures of teeth or direct restorations) Intraoral clinical evaluation[b]
Granell-Ruíz et al,[31] 2014; Spain (laminate veneers)	70 participants /53 women (75.7% of sample) 323 teeth	**Bruxism** 30 (42.9%) Occlusal guard (n=15) **Control** 40 (57.1%)	46 y (18-74)	36-132	Clinical inspection of teeth (consequences of clenching or grinding activities, visible in dentition and consistent with bruxing habit)
Monaco et al,[29] 2013; Italy (single crowns)	398 participants /261 women (65.6% of sample) 1132 teeth	**Bruxism** 125 (31.4%) Occlusal guard (n=66) **Control** 273 (68.6%)	48.6 (18-84)	12-60	Presence of parafunctions (clenching or bruxism); Parafunctions in combination with the absence of wear facets
Simeone and Gracis,[30] 2015; Italy (single-crowns)	107 participants /73 women (68.2% of sample) 275 teeth	**Bruxism** 25 (23.5%) **Control** 82 (76.5%)	52 ±15	12-132	Occlusal signs and clinical symptoms of bruxism
Smales and Etemadi,[24] 2004; Australia (onlays)	50 participants//n women (not reported) 97 teeth	**Bruxism** 10 (20%) Occlusal guard (n=not reported) **Control** 40 (80%)	Not reported	12-72	Matching facets on extensively worn opposing teeth and enlargement of masseter muscles

CI, confidence interval; HR, hazard ratio; OR, odds ratio; RR, relative risk; SB, sleep bruxism. [a]Estimated by reviewers. [b]Information obtained by email contact with corresponding author.

Table 1. *(Continued)* Summary of descriptive characteristics of included articles (n=8)

Region (Anterior and/or Posterior) and Type of Ceramic	Failure, n (%)	Survival Rate (%/y)	Findings (RR, OR, HR, n/%, Correlation Provided)	Main Conclusion Related to SB	Study Design
Anterior Veneers (n=318) **Type** Silicate (feldspathic porcelain, leucite heat-pressed ceramic, or lithium disilicate heat-pressed ceramic)	29 failures (9.8%)	94.4% 5 y 94.1% 8 y 93.5% 10 y 85.7% 15 y 82.9% 20 y	HR=7.74 CI (2.5-24.14) CI=95% (*P*=.001)	7.7-times greater risk of failure associated with existing parafunction	Retrospective cohort study
Anterior and posterior Single-crowns (n=470) Veneers (n=318) Onlays (n=213) Inlays (n=334) **Type** Glass-ceramics	95 failures (8,4%)	97.3% 5 y 95.6% 8 y 93.5% 10 y 85.8% 15 y 78.5% 20 y	HR=2.31 CI (1.28-4.06) CI=95% (*P*=.004)	For all restoration types, determined risk 2.3 times higher for failure in bruxers	Retrospective cohort study
Posterior Onlays (n=213) Inlays (n=334) Single-surface inlays (n=38) Two-surface inlays (n=141) Three-surface inlays (n=155) **Type** Glass-ceramics	27 failures (4.9%)	**Onlays** 98.9% 5 y 99.1% 8 y 92.4% 10 y 92.4% 20 y **Inlays** 98.9% 5 y 97.3% 8 y 96.8% 10 y 87.2% 15 y 81.5% 20 y	No greater risk of failure (*P*=.408)	No increased failure rate associated with bruxism	Retrospective cohort study
Anterior and posterior (teeth) Single-crowns (n=428) Veneers (n=318) Onlays (n=62) **Type** Lithium disilicate	25 failures in tooth supported restorations (3.1%)	**Anterior crown** **Veneered** 97.5% 5 y **Monolithic** 95.7% 5 y **Posterior crown** **Veneered** 95.4% 5 y **Monolithic** 96.1% 5 y **Anterior veneer** **Veneered** 96.3% 5 y **Monolithic** 100% 5 y **Posterior veneer** **Veneered** 100% 5 y **Monolithic** 100% 5 y **Onlay Veneered** 100% 5 y **Monolithic** 97.8% 5 y	33% of mechanical complications, fractures and chipping occurred in participants with parafunctions 261 restorations (257 tooth supported) 5 failures[a] (All tooth supported)	Lithium disilicate may be considered valid option to treat patients with SB, especially using monolithic restorations, as they did not show any structural complications	Retrospective cohort study
Anterior Veneers (n=323) **Type** Leucite reinforced glass-ceramic	42 failures (13%)	**Debonding***100% 2 y 97.2% 4 y 97.2% 6 y 87.4% 8 y 83.2% 10 y **Fractures**[a] 95.2% 4 y 91.9% 6 y 86.8% 8 y 85.2% 10 y	**Debonding** 29 (22 in bruxism group) (*P*=.009) **Fractures** Not statistically significant (*P*=.511)	Probability of debonding almost 3 times higher in participants with bruxism	Retrospective cohort study
Anterior and posterior Single-crowns (n=1132) Anterior (n=343) Posterior (n=789) **Type** Zirconia	**Success Rate criteria** 65 failures (5.74%)	**Cumulative Success Rate** **Anterior** 100% 1 y 100% 2 y 85.6% 3 y 100% 4 y 100% 5 y Total 96.2% **Posterior** 97.5% 1 y 93.7% 2 y 87.5% 3 y 90.2% 4 y 95.2% 5 y Total 93.4%	**All restorations** OR=2.60 CI (1.6-4.24) **Light bruxism** OR=0.93 CI (0.4-2.16) **Moderate bruxism** OR=2.62 CI (1.38-4.98) **Severe bruxism** OR=3.29 CI (1.62-6.72) CI=95%	Technical complications few and limited primarily to participants with parafunction (bruxism or clenching)	Retrospective cohort study
Anterior, posterior and complete mouth reconstruction Single-crowns (n=275) Anterior (n=106) Posterior (n=169) **Type** Lithium disilicate	20 failures (7.27%)	**All restorations**[a] 98.9% 2 y 98.6% 4 y 98.3% 6 y 98.3% 11 y	Only one of crowns failed in bruxer	Significantly low crown failure rate in group with bruxism	Retrospective cohort study
Posterior Onlays (n=19) Without metal reinforcement (n=78) **Type** Sintered feldspathic	21 failures in onlays without metal reinforcement (26.9%)	**Without metal reinforcement**[a] 87.8% 1 y 80% 2 y 72% 3 y 69.4% 4 y 60% 5 y 60% 6 y	7 fractured onlays seen in 4 participants with evidence of parafunctional habits (without metal reinforcement)	Relatively higher numbers of onlay failures occurred in participants with parafunctional habits (29.2%) than in those without (24.7%) (Fisher exact test, *P*=.420)	Retrospective cohort study

Table 2. MAStARI risk of bias summarized assessment

Author	Risk of Bias
Beier et al[25] (2012)	High
Beier et al[26] (2012)	High
Beier et al[27] (2012)	High
Fabbri et al[28] (2014)	Moderate
Granell-Ruíz et al[31] (2014)	Moderate
Monaco et al[29] (2013)	Moderate
Simeone and Gracis[30] (2015)	High
Smales and Etemadi[24] (2004)	High

MAStARI, meta-analysis of statistics assessment and review instrument.

independently screened by 3 reviewers (G.S.M., E.A.B., E.B.S.); studies that did not meet the inclusion criteria were excluded. In phase 2, the same investigators applied these criteria to the full text of the manuscripts. Any disagreements were discussed, and when necessary, a fourth reviewer (T.M.G.) made the final decision.

The data were individually collected by the same reviewers (G.S.M., E.A.B., E.B.S.), and the information was then cross-checked. If necessary, a fourth reviewer (T.M.G.) was involved to solve disagreements. For each included study key features such as follow-up time, SB diagnostic criteria, number of failures, study design, and conclusions were extracted. If required data were not complete, up to 2 attempts were made to contact the corresponding author.

The risk of bias was independently assessed by the reviewers (G.S.M., E.A.B., E.B.S.), using the meta-analysis of statistics assessment and review instrument (MAStARI) developed by the Joana Briggs Institute.[22] In case of disagreements, a fourth reviewer (T.M.G.) made the final decision. A checklist consisting of 9 questions was applied, in which possible answers were "yes," "unclear," "no," or "not applicable." The comprehensive risk of bias was considered high if the study reported a "yes" score of up to 49%, moderate if between 50% and 69%, and low if more than 70%. Figures were generated using software (Review Manager 5.3; the Cochrane Collaboration). Outcomes measured by means of hazard ratios (HRs), odds ratios (ORs), relative risks (RRs), and survival rates (%/years) were considered, as well as findings reported in absolute or relative frequencies. Moreover, subgroups based on restoration region, type of prosthesis, and type of ceramic material were planned. Heterogeneity was assessed with the I^2 statistic, and a meta-analysis of the results was performed using software (Review Manager 5.3; the Cochrane Collaboration) (α=.05). The Grading of Recommendations Assessment, Development and Evaluation (GRADE) summary of findings table (Table 3) was used to verify the overall quality of evidence. Tables were generated using online software (GRADEproGDT; the GRADE Working Group).[23]

RESULTS

The search across electronic databases identified 1162 studies, and after the duplicate references had been removed, 672 records remained. In addition, 58 studies were identified from the nonpeer-reviewed literature. No studies were included as a result of hand searching the reference lists, and the experts did not provide any additional references. The reviewers considered 29 studies for eligibility, of which 21[33–53] were excluded after full-text reading (Supplemental Table 2), and 8 studies were subsequently included for qualitative analysis. Figure 1 shows a flowchart describing the complete process of identification, inclusion, and exclusion.

Of the 8 included studies, 1 was conducted in Australia,[24] 3 in Austria,[25–27] 3 in Italy,[28–30] and 1 in Spain.[31] All of them were retrospective cohort studies. The age of the participants ranged between 19 and 71 years of age and the follow-up time between 12 and 261 months. Considering ceramic restorations, fracture was observed as the main reason for failure in most of the studies,[24–27] followed by debonding[30,31] and chipping.[28] Sleep bruxism was diagnosed by means of a questionnaire and clinical inspection in a single study[28]; the others reported clinical evaluation alone. Table 1 summarizes the descriptive characteristics of the included studies.

Regarding the overall risk of bias, 3 studies were considered at moderate risk,[28,29,31] and 5 at high risk.[24–27,30]

Table 3. GRADE summary of findings[f]

Quality Assessment							No. Participants		Effect			
No. of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other Considerations	Bruxism	Control	Relative (95% CI)	Absolute (95% CI)	Quality	Importance
OR for ceramic restoration failures												
5	Observational studies	Very serious[a,b,c]	Serious[d]	Not serious	Serious[e]	None	242	695	**OR 1.10** (0.43-2.80)	Not estimated	⊕◯◯◯ VERY LOW	
HR for ceramic restoration failures												
3	Observational studies	Very serious[a,b,c]	Serious[d]	Not serious	Serious[e]	None	105	196	**HR 2.31** (1.30-4.10)	Not estimated	⊕◯◯◯ VERY LOW	

CI, confidence interval; GRADE, Grading of Recommendations Assessment, Development and Evaluation; HR, hazard ratio; OR, odds ratio; SB, sleep bruxism. [a]Samples not representative of population as whole. [b]Majority of studies did not provide reliable information concerning SB diagnosis. [c]Confounding factors not identified or reported. [d]High clinical, methodological and statistical heterogeneity across studies. [e]Discrepancies in effect measures across studies. [f]Question: is SB associated with increased occurrence of failures in ceramic restorations?

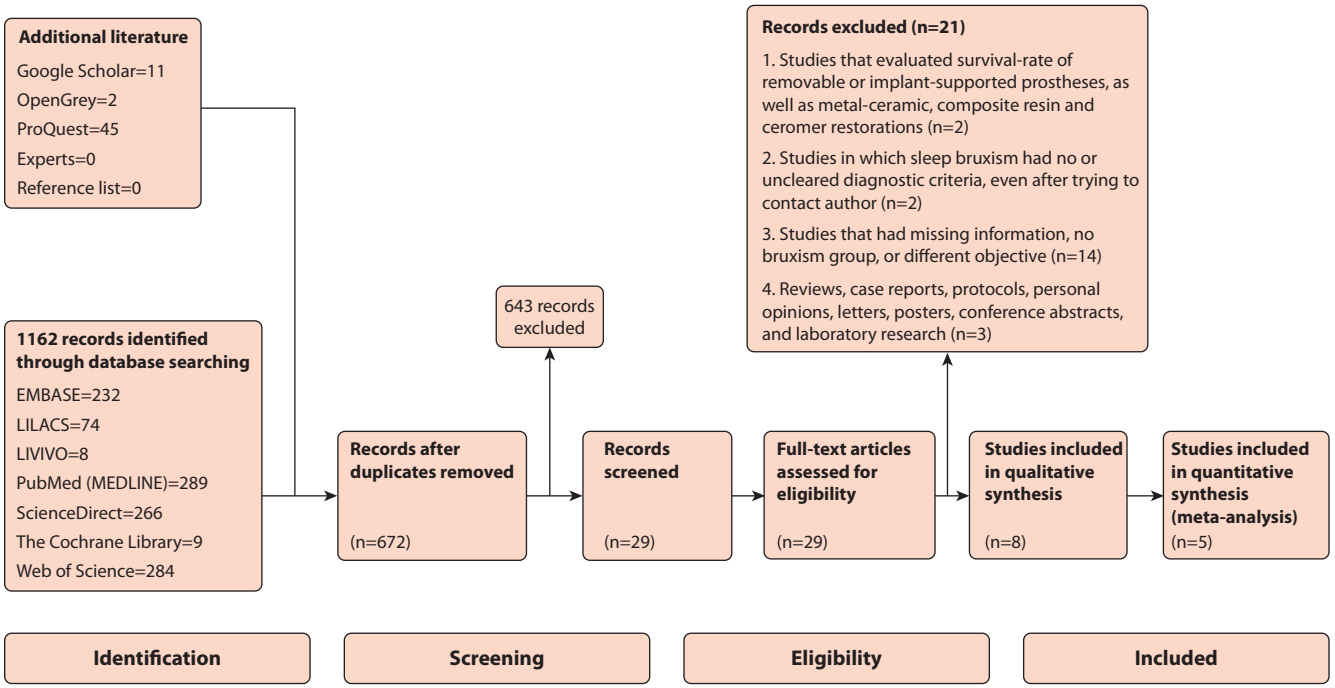

Figure 1. Published articles search and selection criteria.

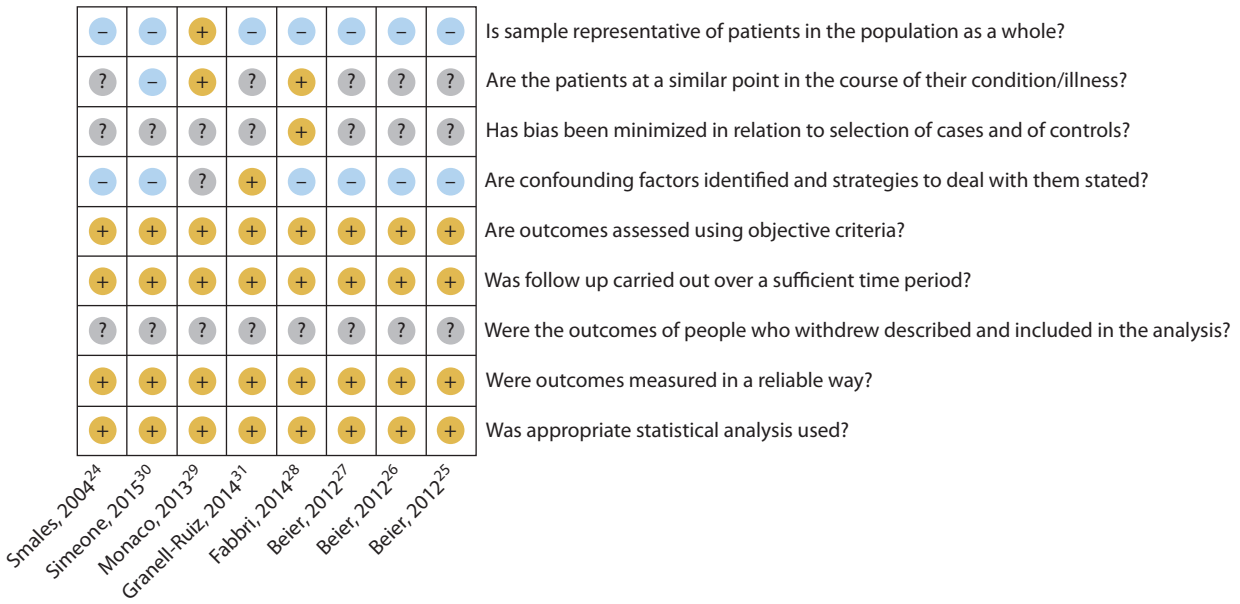

Figure 2. Risk of bias for cohort studies assessed by using MAStARI critical appraisal tools. MAStARI, Meta-Analysis of Statistics and Review Instrument.

Only a single study was considered at low risk of selection bias because further information about the questionnaire was provided by email contact with the corresponding author (G. Fabbri, personal communication, October 04, 2016).[28] More information regarding the risk of bias evaluation is available in Figure 2 and Table 2.

Considering results of individual studies, Beier et al[25] evaluated the long-term survival rate of 1335 ceramic restorations up to 20 years. The sample was composed of 302 participants, of which 106 were bruxers. An increased cumulative risk of failure was reported concerning the SB group (HR=2.31; 95% confidence interval [CI]=1.30 to 4.10). The authors conducted another study to assess the clinical performance of glass-ceramic inlays and onlays in posterior teeth, and of 120 participants, 40 were bruxers.[26] The results of this study demonstrated that a single failure occurred in the SB group; therefore, no statistical

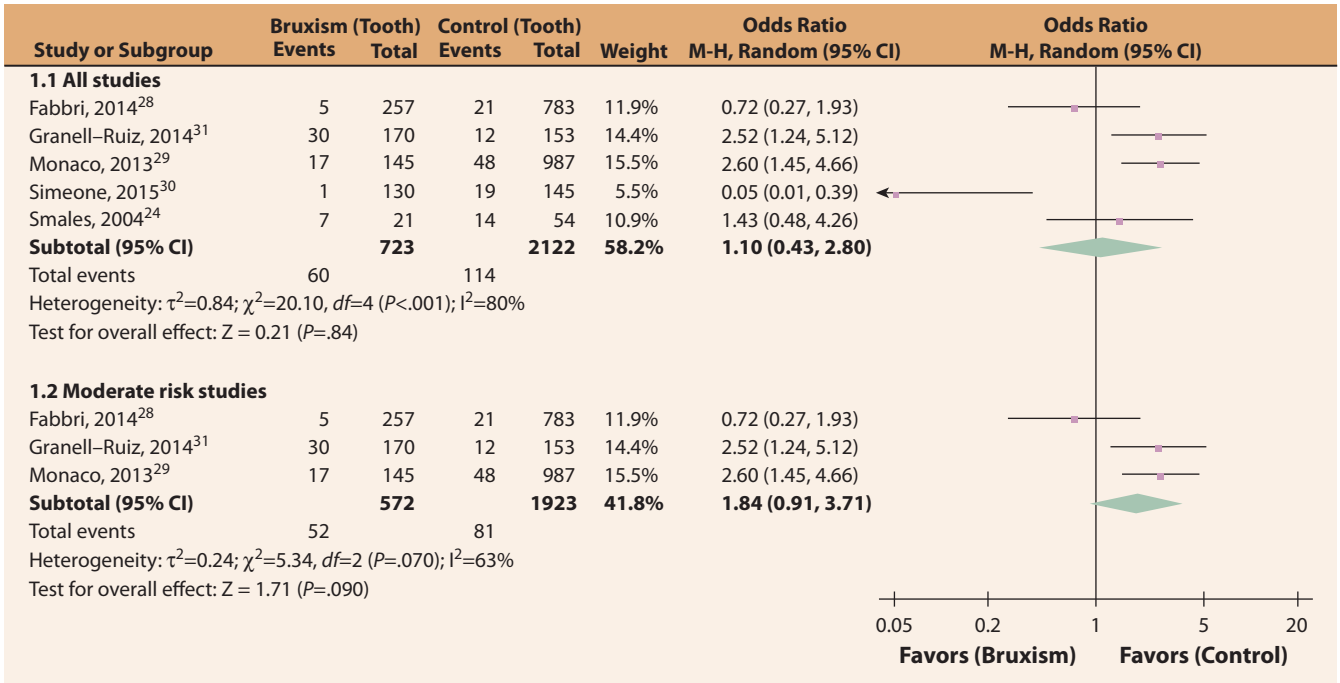

Figure 3. Bruxism association with ceramic restoration failures. Results from 2 meta-analyses. 1.1, Forest plot for overall odds ratio. 1.2, Forest plot for overall odds ratio considering solely studies classified as moderate risk of bias. CI, Confidence interval.

analysis was performed and no association was reported. Beier et al[27] also evaluated the clinical performance of anterior ceramic veneers for up to 20 years in 84 participants, half of whom had diagnoses of SB. An increased cumulative risk of failure over time was reported in the SB group (HR=7.74; 95% CI=2.50 to 23.95).

Fabbri et al[28] evaluated 860 anterior and posterior lithium disilicate restorations placed over 5 years, and of 312 participants, 52 were bruxers. The corresponding author provided additional data regarding sample characteristics within the SB group (G. Fabbri, personal communication, November 16, 2016). Based on the results of this study, no correlation was found between SB and the occurrence of failures (estimated by the systematic review reviewers; OR=0.72; 95% CI=0.27 to 1.92).

Granell-Ruíz et al[31] investigated the influence of bruxism on the survival of anterior ceramic veneers in 70 participants, of which 30 were bruxers. The findings of this study suggest that SB is related to increased odds of failure (estimated by the systematic review reviewers; OR=2.52; 95% CI=1.24 to 5.12).

Monaco et al[29] evaluated 1132 zirconia-based single crowns to gather the outcomes over 1 to 5 years after restoration placement. The sample was composed of 398 participants, of which 125 were bruxers. Greater odds of failure related to SB were found in the moderate (OR=2.62; 95% CI=1.38 to 4.98) and severe (OR=3.29; 95% CI=1.62 to 6.72) groups, and the overall OR was 2.6 (95% CI=1.60 to 4.24).

Simeone and Gracis[30] conducted a study to assess 275 veneered lithium disilicate single crowns cemented over 11 years in 106 participants, of whom 25 were bruxers. Furthermore, of the 20 restoration failures observed, only 1 occurred in the SB group, demonstrating a significantly low failure rate. Therefore, no correlation between failure and SB was confirmed (estimated by the systematic review reviewers; OR=0.05; 95% CI=0.01 to 0.39).

Smales and Etemadi[24] investigated the survival of sintered feldspathic ceramic onlays placed with and without metal reinforcement. The sample was composed of 50 participants, of whom 10 were bruxers. Based on the results of this study, no association between SB and ceramic restoration failure could be observed (estimated by the systematic review reviewers; OR=1.43;95% CI=0.48 to 4.26).

A meta-analysis was performed for dichotomous outcomes in 5 studies by using OR and the Mantel-Haenszel analysis method.[24,28-31] Although subgroup analysis was planned in the protocol, none was performed because of the limited number of finally included references. Three studies from the same authors were not included in the meta-analysis because the OR could not be estimated from the reported data.[25-27] In addition, since sample characteristics suggested that the same participants were included across these studies, no combined analysis was performed as it could have under- or overestimated the effect measure.

Limited data from the meta-analysis and from the restricted number of included studies imply that

differences in the overall odds of failure concerning SB and other types of ceramic restorations did not favor or disfavor any association (OR=1.10; 95% CI=0.43 to 2.80). High values for the I^2 and Tau^2 tests were observed, indicating that included studies were notably heterogeneous in their reported effect size. Furthermore, a meta-analysis considering only studies classified as moderate risk of bias was performed; the overall OR was slightly higher, although still not statistically significant (OR=1.84; 95% CI=0.91 to 3.71). Figure 3 summarizes the results from the meta-analysis. In addition, the confidence in cumulative evidence was considered very low because of high risk of bias, heterogeneity and imprecisions observed within the included studies. The summary of these findings can be found in Table 3.

DISCUSSION

The lack of strong evidence concerning this topic did not permit the authors to answer the posted question definitively. Studies were considered heterogeneous, as substantial variability was found in the study design, sample size, ceramic material, and SB diagnostic criteria. Furthermore, the high values observed for the I^2 test suggested that studies included in the meta-analysis were heterogeneous, basically because of inconsistent results from two of the included studies.[28,30] Both showed considerably lower restoration failure-rates in the SB group than in the control group. This finding was not expected since failures should occur similarly in both groups. In addition, methods used to diagnose SB were poorly or not described and were not fully reliable. Similar difficulties were observed in a previous systematic review focused on the survival of veneered zirconia restorations in prospective studies.[32] For these reasons, conclusions must be interpreted with caution, and, ideally, further studies should use standardized and validated methods.

Also, consensus on SB diagnostic criteria is lacking in the literature. Nevertheless, a grading system has been proposed by Lobbezoo et al,[15] which suggests that SB can be classified into "possible" by means of questionnaires or clinical evaluation alone, "probable" if questionnaires are associated with clinical inspection, and "definite" if a polysomnography examination is performed. According to this grading system, as most of the included studies reported solely on clinical examination,[24-27,29-31] they should be classified as possible SB. Only a single study in which a questionnaire was associated with clinical inspection, could be classified as probable SB.[26] Still, as no polysomnographic examination was performed to fully confirm the diagnosis, none could be classified as definite SB.

Despite these critical qualifications, the results from the meta-analysis (Fig. 3) revealed no overall increased odds of failure regarding ceramic restorations in SB participants. However, when analyzed alone, anterior ceramic veneers showed increased HR and OR in the SB group.[27,31] Five studies provided hard acrylic resin occlusal guards,[24,26,27,29,31] which were analyzed as a cofounding factor. These guards were thought to reduce the occlusal load on both anterior and posterior restorations during the night, possibly reducing the failure rates.[12]

Most of the included studies did not report which failure occurred within the groups, making a further evaluation of these data impossible. In addition, a minimum follow-up of 1 year after cementation was reported in 4 studies,[24,28,29,30] and a minimum of 3 years was reported in 1 study.[31] They should be considered short-term studies. Three studies reported a mean follow-up of 102 ±60 months,[25] 111 ±63 months,[26] and 118 ±63 months[27] and were considered long-term. Since the association between SB and failures in ceramic restorations was not clarified by the results of this systematic review, further studies with long-term analysis may detect any association more accurately.

Another concern is that 3 studies evaluated ceramic materials with different flexural strengths and fracture resistances in the group of glass-ceramics, potentially affecting the results.[25-27] The different types of ceramics used across the included studies did not permit a clear judgment as to whether alterations in observed failure rates were attributable to the type of restoration or type of ceramic. In addition, posterior restorations may have been more susceptible to failure than anterior restorations because of the greater occlusal load.[5] Once again, because of the different materials used across studies, this hypothesis could not be confirmed.

Regarding the fabrication process, a single study compared monolithic and veneered restorations with the enrollment of SB participants.[28] Although monolithic restorations presented better results, further studies are needed to confirm this finding, especially with zirconia frameworks; the different physical properties of zirconia-based veneers and the restoration core could lead to crack propagation.[8]

CONCLUSIONS

Within the limitations of this systematic review, the following conclusions were drawn:

1. Only anterior ceramic veneers showed increased hazard and odds of failure for participants with sleep bruxism.
2. However, the overall result from the meta-analysis did not favor any association between sleep bruxism and increased odds of failure for ceramic restorations.

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