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ORIGINAL ARTICLE

Association between signs and symptoms of bruxism and presence of tori: a systematic review

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Abstract

Objective This systematic review aims to answer the question: "Is there an association between any specific signs and symptoms of bruxism and the presence of tori?"

Material and methods Observational studies, which evaluated the association between signs and symptoms of bruxism and tori, were selected. Signs and symptoms of bruxism (such as teeth grinding, jaw clenching, abnormal tooth wear, facial muscle hypertrophy, pain, or fatigue) had to be determined by questionnaire or anamnesis and tori within clinical assessment. Search-strategies were developed for five databases, in addition to three gray literature's databases. The risk of bias was evaluated using the "*Meta-Analysis of Statistics Assessment and Review Instrument*". A summary of overall strength of evidence was estimated using GRADE's Summary of findings table.

Results Among 575 studies, five were included. Two studies were categorized as *moderate risk of bias* and three as *high risk of bias*. Self-report of teeth grinding and/or clenching presented contradictory results. Presence of abnormal tooth wear increased the odds of having tori, mainly for torus mandibularis. The overall quality of evidence ranged from *low to very low*.

Conclusion Based on available evidence, the presence of abnormal tooth wear might be associated with tori, mainly torus mandibularis. There is no sufficient evidence to credit or discredit the association of tori and other signs and/or symptoms of bruxism.

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Clinical relevance Bruxism diagnosis is a challenge. The association between signs and symptoms of bruxism and tori could help clinicians on the recognition of patients susceptible to bruxism. This knowledge might also aid to the understanding of tori's development and stimulate new relevant research.

Keywords Tori · Torus · Bruxism · Tooth wear · Teeth grinding · Systematic review

Introduction

Torus is a slow growth osseous projection in the mandible and/or maxilla due to a combination of genetic and environmental factors [1, 2]. It is formed by dense cortical bone with small amounts of trabecular bone, covered with thin and poorly vascularized mucosa [3]. Tori do not represent a continuous steady growth as they showed a prevalence peak in the third decade and a decrease after the fifth decade of life [4]. These conditions are rarely known to affect children [5, 6].

Population studies have shown a variable prevalence, ranging from 3% in Nigeria, rising to around 20 to 30% in Thailand and Brazil and even as high as 74% in Japan [5, 7–9]. Among females, they have been often localized on the palatal side of the maxillary bone (i.e., torus palatinus (TP)), while Among males they affected mainly the mandible (i.e., torus mandibularis (TM)) [10].

The etiology of tori is not completely known. Occlusal overload have been suggested by some studies to be involved in the pathogenesis of tori [6, 11–15]. However, available data are inconsistent. One hypothesis is based on the Wolff's law [16], if loading on a particular bone increases, the bone will remodel itself over time to become stronger. Stress and stretch over the osteogenic-periostea may also lead to bone deposition in the form of tori [17].

Occlusal overloads in bruxers can be potentially caused by increased masticatory muscle contractions causing teeth clinical complications [18]. Bruxism has two distinct circadian manifestations; it might occur during sleep (sleep bruxism-SB) or during wakefulness (awake bruxism-AB) [19]. In addition, bruxism's signs and symptoms may vary according to the patient. It might include signs such as teeth grinding, abnormal tooth wear, indented tongue, muscle hypertrophy, and jaw locking, and symptoms like morning headache; facial pain, or fatigue; reports of teeth grinding or jaw clenching sounds during sleep (by the sleep partner or self-report) [20]. To establish a concept, it is important to note that a sign is any objective evidence of disease, while a symptom is any subjective one. Therefore, a symptom is a phenomenon that is experienced by the affected individual, while a sign could be measured or detected by someone other than the affected individual [21, 22].

A positive association between TM and SB has been suggested by a previous review [14]. A new systematic review (SR) is proposed to specifically establish which signs and/or symptoms of bruxism are associated with tori in addition to expand and update the search strategy with the use of additional databases. Therefore, the aim of this SR is to answer the following structured question: "Is there an association between any specific signs and symptoms of bruxism and the presence of tori?"

Methods

Protocol and registration

This SR was carried out adhering to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Checklist (PRISMA) [23]. The study protocol was registered at the Prospective Register of Systematic Reviews [24] (PROSPERO, Centre for Reviews and Dissemination, University of York, Heslington, York, United Kingdom; and the National Institute for Health Research, London, United Kingdom) under number CRD42016042073 [25].

Eligibility criteria

Inclusion criteria

Observational studies, which evaluated the association between signs and symptoms of bruxism and the presence of tori, were included. No publication time, age, or sex restrictions were applied. Only articles in Latin-Roman alphabet were accepted. The presence of tori had to be determined within clinical assessment by a dentist or other qualified oral health-care provider. Signs and symptoms of bruxism had to be evaluated by using questionnaires and/or interviews. The *signs* of bruxism that were considered are the following: (1) teeth grinding and/or clenching, (2) jaw clenching, (3) abnormal tooth wear, (4) masticatory muscle hypertrophy, and (5) indented tongue. The *symptoms* that were considered are reports of (1) jaw-muscle fatigue, (2) morning headache, (3) facial pain or fatigue, (4) teeth grinding or jaw clenching sounds during sleep (reported by the family or the sleep partner), and (5) teeth grinding and/or clenching self-awareness.

Exclusion criteria

The following exclusion criteria were applied: (1) reviews, letters, posters, conference abstracts, case reports, and personal opinions, (2) studies in which plaster models were used for the analyses, with no direct clinical examination, (3) studies in which the sample included craniofacial genetic syndromes or neuromuscular diseases, (4) studies in which diagnostic criteria or signs and symptoms of bruxism were not reported or could not be categorically discerned, (5) studies with different objectives (tori and/or signs and symptoms of bruxism were evaluated or cited in the text, but not statistically associated), and (6) studies in which sample was already reported in another included study by the same author.

Information sources

Detailed individual search strategies for each of the following bibliographic databases were developed: Embase, Latin American and Caribbean Health Sciences (LILACS), PubMed (including Medline), ScienceDirect, and Web of Science. In addition, a gray literature search was performed on Google Scholar, OpenGrey, and ProQuest Dissertations & Theses Global. More information on the search strategies is provided in Appendix 1 (found in the supplemental data in the online version of this article). Additional articles were identified by a hand-search of the reference sections of included manuscripts. In addition, experts were approached to identify any missing important publication. Experts were identified based on the list of studies included in phase two (full-text reading). The criterion should be an author who has two or more publications about this topic, weather as a first or a senior author. Also, other experts were identified on Scopus by analyzing the results of the proposed search strategy. They were contacted by email and asked to identify the five most important publications regarding the topic.

Search

Appropriate truncation and word combinations were selected and adapted for each electronic database. All references were managed by the software EndNote (EndNote X7® Basic-Thomson Reuters, New York, EUA), and duplicated hits were removed. The end search date across all databases was May 26, 2016.

Study selection

Included studies were selected following a two-phase process. In phase one, two reviewers (EB, JSB) independently evaluated the titles and abstracts of all identified electronic database citations. Any studies that did not appear to fulfill the inclusion criteria were discarded. In phase two, the same selection criteria were applied to the full articles to confirm their eligibility. The same reviewers (EB, JSB) performed this step. Any disagreements in either phase were solved by discussion and mutual agreement between the reviewers. A third reviewer (ALP) was involved when the reviewers did not reach a consensus required to make a final decision.

Data collection process and data items

Two reviewers (EB, JSB) performed the data collection process independently. After the individual collection, all of the information was crosschecked to ascertain the completeness of the retrieved data. Any disagreements were solved by mutual agreement between the authors.

The following information was recorded from all included studies: authors, year of publication, country, sample size and characteristics, reported signs and/or symptoms of bruxism, findings, main conclusion, and study design. If the required data was not included in articles, attempts were made to contact the authors to retrieve the missing information.

Risk of bias within the studies

Risk of bias of included studies was evaluated by two independent reviewers (EB, JSB) using the Meta-Analysis of Statistics Assessment and Review Instrument (MAStARI) for observational studies from the Joana Briggs Institute [26]. Disagreements between the reviewers were solved by discussion and mutual agreement, and when necessary, a third author (ALP) made the final decision. Two different MAStARI questionnaires were used based on the included studies (cross-sectional or case-controlled studies). Both questionnaires consisted of nine questions, with the following possible answers: “yes” (for low risk of bias), “no” (for high risk of bias), and “unclear” or “not applicable.” Then, according to the achieved answers, the comprehensive risk of bias of each included study was considered as low, moderate or high [26]. Figure 2 was generated with the aid of RevMan software (Review Manager 5.3, Copenhagen, Denmark) provided by the Cochrane Collaboration [27].

Summary measures

Risk ratios (RRs) and odds ratios (ORs) for dichotomous outcomes, with 95% confidence intervals (CIs), were considered as well as the mean differences or standardized mean differences for continuous outcomes.

Synthesis of results

A qualitative descriptive analysis of the results was performed [28]. A meta-analysis was planned if the data from the included studies were considered relatively homogeneous.

Confidence in cumulative evidence

A summary of the overall strength of evidence was presented using "Grading of Recommendations Assessment, Development and Evaluation" (GRADE) Summary of Findings tables, produced with the aid of the GRADE online software (GRADEpro GDT, Copenhagen, Denmark), provided by the GRADE Working Group, in association with the Cochrane Collaboration and Members of McMaster University [29].

Results

Study selection

The first selection process resulted in 262 articles across electronic databases. Duplicate articles were then removed, decreasing the amount to 181 studies. In addition, 313 studies were identified from the gray literature. After title and abstract reading, a total of 23 potentially useful studies for full-text reading were acquired. Thereafter, 18 articles were excluded by using eligibility criteria (see Appendix 2). Thus, only five articles were finally included for quantitative and qualitative analysis. All of these studies were initially identified through the main electronic databases search. The experts provided no additional references. Figure 1 shows a flowchart describing the complete process of identification, inclusion, and exclusion of studies.

Study characteristics

Out of the five included studies, mean age for the samples ranged from 32 [6] to 66 [30], while most of the samples within studies are around 41 to 47 [12, 31]. Two studies were case-controls, one was conducted in Brazil [12] and another one in Canada [32]; while the other three studies were cross-sectionals, conducted in Japan [30], Jordan [31], and Thailand [6]. Within included studies, abnormal tooth wear was the most frequently studied sign [12, 31, 32], followed by the symptom self-report of teeth grinding and/or clenching [30, 31]. Other signs and/or symptoms, described in the inclusion criteria section, were not evaluated in the included articles. Table 1 summarizes the descriptive characteristics of the included studies.

Risk of bias within studies

None of the studies fulfilled all MAStARI methodological criteria. Two studies were categorized as *moderate risk of bias* [12, 30] and three as *high risk of bias* [6, 31, 32]. It is worth noting that the question "was the follow-up carried out over a sufficient time period?" was considered not applicable for the included studies, since none of them proposed longitudinal results. None of the studied samples was representative of the population as a whole or based on a random/pseudorandom sample (method was absent or poorly described). Two studies [12, 30] were considered moderate risk of bias due to their detailed description of their methodologies, establishing more precise criteria to evaluate their proposed outcomes. The results of the risk of bias evaluation can be found on Table 2 and Fig. 2.

Results of individual studies

De Luca Canto et al. [12] conducted a case-control study to assess the association between TM and its size with abnormal tooth wear, self-report of teeth grinding, and other variables related to parafunctional activity. The sample was divided into two groups matched for age and sex. Case group was composed by 100 individuals with TM, and control group was composed by 100 individuals without TM. They concluded that the presence of abnormal tooth wear increases the odds of having TM by 20 times (OR = 20.89; 95%CI = 8.36–52.02). The authors provided additional data, available in the complete study thesis [33], about abnormal tooth wear and self-report of teeth grinding, individually. From the case group, 83 presented abnormal tooth wear and 76 reported teeth grinding, while in the control group, 33 presented abnormal tooth wear and 54 reported teeth grinding (calculated by the SR authors, Abnormal tooth wear OR = 9.91; 95%CI = 5.08–19.33; Self-report of teeth grinding OR = 2.70; 95%CI = 1.47–4.49).

Kerdpon and Sirirungrojying [6] investigated whether TM or TP had an association with occlusal overload. Six hundred and nine individuals were examined. Subjects were diagnosed with parafunctional activity (group "present"), if at least three interview criteria were satisfied and at least one clinical sign was present (shiny occlusal and incisal facets and other signs were clinically assessed). Data was analyzed by logistic regression (adjusted for sex and age), revealing a strong association between the presence of TM and "self-report of teeth grinding with abnormal tooth wear or other physical signs of bruxism" (OR = 25.30; 95%CI = 15.65–40.92). Patients in the group classified as "questionable" for having parafunctional activity were also more likely to have TM than those in the "absent" group (OR = 4.95; 95%CI = 1.64–14.91).

To estimate if various mechanical and systemic factors are associated with an increased odds for the presence of oral tori, Morrison, and Tamimi [32] conducted a case-control study. The sample was composed by 66 subjects with TM, 34 subjects with TP, and 100 controls. The ORs were adjusted for the potential confounders such as age, sex, smoking habit, medical history, and signs of tooth attrition. Both TM and TP were highly associated with abnormal tooth wear (adjusted OR = 38.18; 95% CI = 7.20–202.41 for TP, adjusted OR = 6.69; 95% CI = 2.78–16.14 for TM).

Sawair et al. [31] carried out a cross-sectional study to determinate the prevalence and clinical characteristics of tori and jaw exostoses. They analyzed 618 patients, of whom 214 had tori (TP, TM or both), 159 patients had TM, while 113 had TP. Abnormal tooth wear was classified into "no," "mild to moderate," or "severe," and patients were asked about self-awareness of parafunctional activity. Groups of patients who had abnormal tooth wear "mild to moderate" (N = 259; TM = 103(39.8%); TP = 51(19.7%)), or "severe" (N = 10; TM = 2(20%); TP = 8(80%)), as well as "self-report of teeth

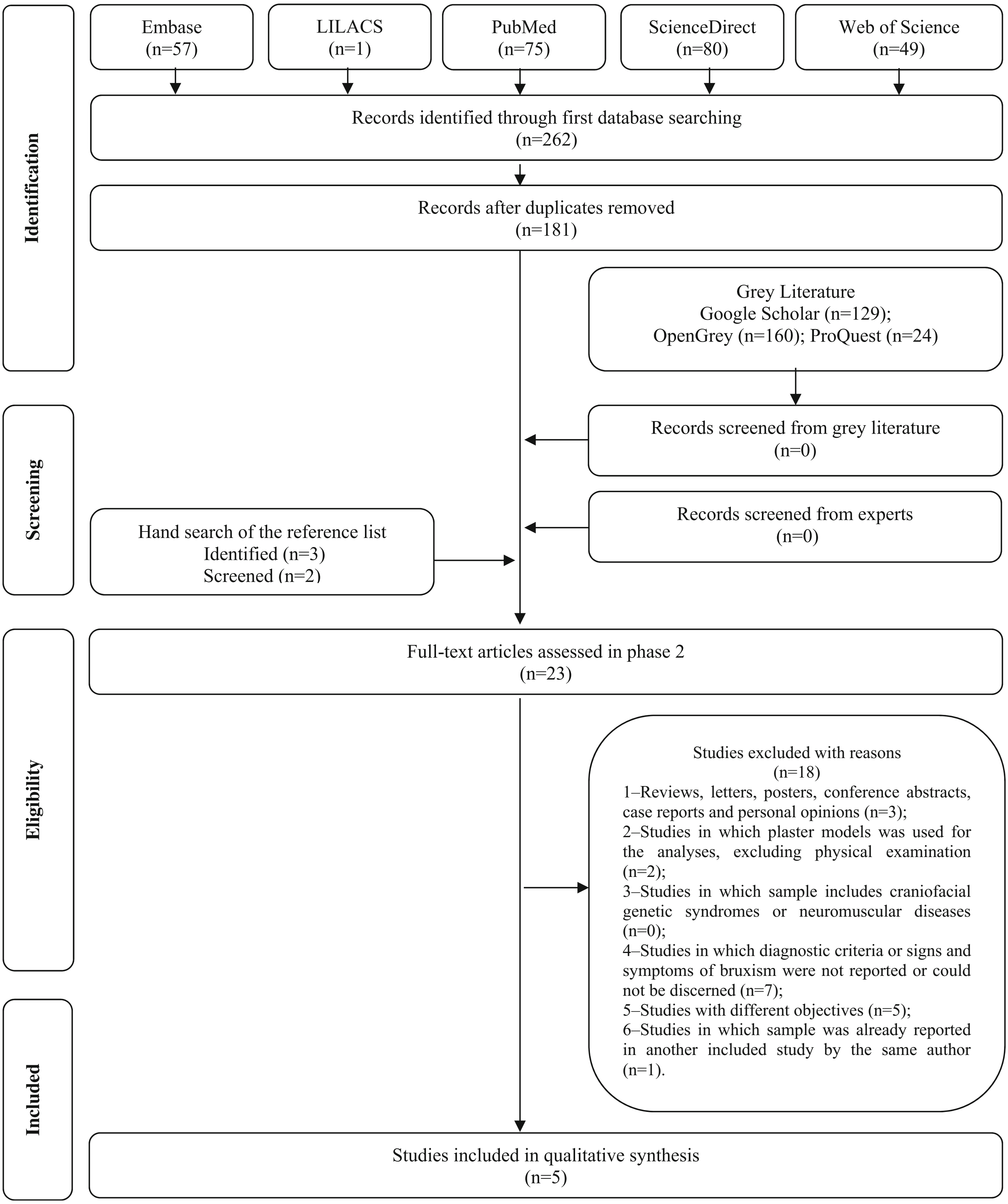

Fig. 1 Flow diagram of literature search and selection criteria (Adapted from PRISMA)

grinding" (N = 85; TM = 29(34.1%); TP = 25(29.4%)), had significantly more prevalent torus (TM and/or TP).

Yoshinaka et al. [30] conducted a cross-sectional study with the purpose of examine the prevalence of TP among

Table 1 Summary of descriptive characteristics of included studies ($n = 5$)

Author/Year/Country	Case (*N* female/%)	Control (*N* female/%)	Age in years (range, mean ± SD)	Signs and symptoms of bruxism analyzed	Findings (*N*, %, OR, RR, correlation if provided)	Main conclusion	Study design
De Luca Canto et al./2012/ Brazil [12]	TM = 100 F:*N* = 33/67%	100 F:*N* = 67/67%	20–62 41 ± 10.5***	SB* with abnormal tooth wear	OR =20.89; 95%CI = 8.36–52.02 Correlation $r = 0.516$ ($p < 0.001$)	Strong association between TM and SB* with abnormal tooth wear. There is no relevant evidence showing that self-perception have an association with the presence of TM.	Case-control
				SB* without abnormal tooth wear	OR =4.122; 95%CI = 1.35–12.51 Correlation $r = 0.233$ ($p = 0{,}001$)		
Kerdpon and Sirirungrojying/1999/ Thailand [6]	TM = 182 F:*N* = 125/68.7%	427 F:*N* = 301/70.5%	10–80 32.1 ± 14.2	Bruxism** with abnormal tooth wear or other clinical sign	TM *N* = 125 (75.3%) OR = 25.30; 95%CI = 15.65–40.92	Occlusal stress indicated by clenching and/or grinding is associated with the occurrence of TM. TM cannot be a consistent indicator of parafunction as some patients without parafunction had TM.	Cross-sectional
	TP = 376 F:*N* = 288/76.6%	233 F:*N* = 138/59.2%			TP *N* = 101 (60.8%) OR = 0.96; 95%CI = 0.66–1.40		
Morrison and Tamimi/2013/ Canada [32]	TM = 66 F:*N* = 39/59%	100 F:*N* = 49/49%	TM 12–83 47.3 ± 4.7	Abnormal tooth wear	TM *N* = 38*** (58%; 95%CI = 47–69) AOR = 6.69; 95%CI = 2.78–16.14 ($p < 0.01$)	The subjects with abnormal tooth wear showed an increased risk for the presence of TP and/or TM.	Case-control
	TP = 34 F:*N* = 23/67.6%		TP 14–83 44.5 ± 7.8		TP *N* = 21*** (62%; 95%CI = 45–79) AOR = 38.18; 95%CI = 7.2–202.41 ($p < 0.01$)		
Sawair et al./2009/ Jordan [31]	TM = 159 F:*N* = 59/36.4%*** (*N* total = 618)	NA	10–82 33.6 ± 13.1	Abnormal tooth wear	Moderate: *N* = 259 TM = 103 (39.8%) TP = 51 (19.7%) Severe: *N* = 10 TM = 2 (20%) TP = 8 (80%)	Patients who had abnormal tooth wear had significantly more prevalent TM and/or TP. Abnormal tooth wear and self-report of parafunctional habits (clenching, grinding or bruxism) could be important factors.	Cross-sectional
	TP = 95 F:*N* = 53/55.7%*** (*N* total = 618)			Self-report of teeth grinding and/or clenching	Yes: *N* = 85 TM = 29 (34.1%) TP = 25 (29.4%)		
Yoshinaka et al./2010/ Japan [30]	TP = 113 F:*N* = 91/80.5%***	551 F:*N* = 279/50.6%***	60–82 66.5 ± 4.2	Self-report of teeth grinding and/or clenching	Self-report of AB: *N* = 24*** 21.4% ($p = 0.198$) OR = 1.31; 95%CI = 0.55–3.09 ($p = 0.539$) Self-report of SB: *N* = 21*** 18.6% ($p = 0.933$) OR = 1.13; 95%CI = 0.60–2.12 ($p = 0.705$)	There was no association between the presence of TP with occlusal force, occlusal support, temporomandibular disorders symptoms, or self-reported bruxism.	Cross-sectional

AB awake bruxism, *AOR* adjusted odds ratio, *F* Female, *OR* odds ratio, *SD* standard deviation, *NA* not applicable, *TM* torus mandibularis, *TP* torus palatinus, *SB* sleep bruxism.

*SB was diagnosed with three clinical interview questions, then allocated to the groups with or without abnormal tooth wear

**No differentiation was made between sleep or awake bruxism, and the term parafunction was used instead of bruxism; it was considered as present for parafunctional habits if at least three interview criteria were satisfied and at least one clinical sign of bruxism present

***Calculated by the SR authors

Table 2 Risk of bias summarized assessment

Author	Risk of bias
De Luca Canto et al. [12]	Moderate
Kerdpon and Sirirungrojying [6]	High
Morrison and Tamimi [32]	High
Sawair et al. [31]	High
Yoshinaka et al. [30]	Moderate

Japanese elderly and identify the possible factors associated with its formation. From a total of 664 subjects that responded to a questionnaire and underwent a clinical examination, 113 subjects (17%) presented TP. They concluded that there was no significant association between the prevalence of TP and factors like self-report of teeth grinding. The authors separated results in AB (OR = 1.31; 95%CI = 0.55–3.09) and SB (OR = 1.13; 95%CI = 0.60–2.12).

Synthesis of results

The methodological heterogeneity across studies was considered high to draw reliable results from it. In addition, dividing studies by type of study (cross-sectionals and case-controls) and by tori type (TP and TM) caused a scarce quantity of data for a proper meta-analysis.

Abnormal tooth wear, dental wear, or shiny occlusal/incisal wear facets

Studies that addressed TM [6, 12, 31, 32] were positively associated with abnormal tooth wear, with OR varying approximately from five (calculated by the SR authors; OR = 4.80; 95%CI = 3.22–7.15) [31], seven (adjusted OR = 6.69; 95%CI = 2.78–16.14) [32], and ten (OR = 9.91; 95%CI = 5.08–19.33) [33]. In addition, two studies [6, 12] found high association for patients with bruxism, assessed with questionnaire or anamnesis and presence of clinical signs (OR = 25.30; 95%CI = 15.65–40.92, and OR = 20.89; 95%CI = 8.36–52.02, respectively).

Studies that addressed TP [6, 31, 32] were also positive, with odds ratio varying from four (calculated by the SR authors; OR = 4.04; 95%CI = 2.52–6.48) [31] to 38 (adjusted OR = 38.18; 95%CI = 7.2–202.41) [32]. However, one study [6] found no association for patients with bruxism, assessed with questionnaire or anamnesis and presence of clinical signs (OR = 0.96; 95%CI = 0.66–1.40).

Self-report of teeth grinding and/or clenching

The presence of "self-reported teeth grinding and/or clenching" (assessed only with questionnaire and/or anamnesis) presented contradictory results for both TM and TP.

Studies that addressed TM [12, 31] found positive association. Still, it is important to consider that Sawair [31] assessed

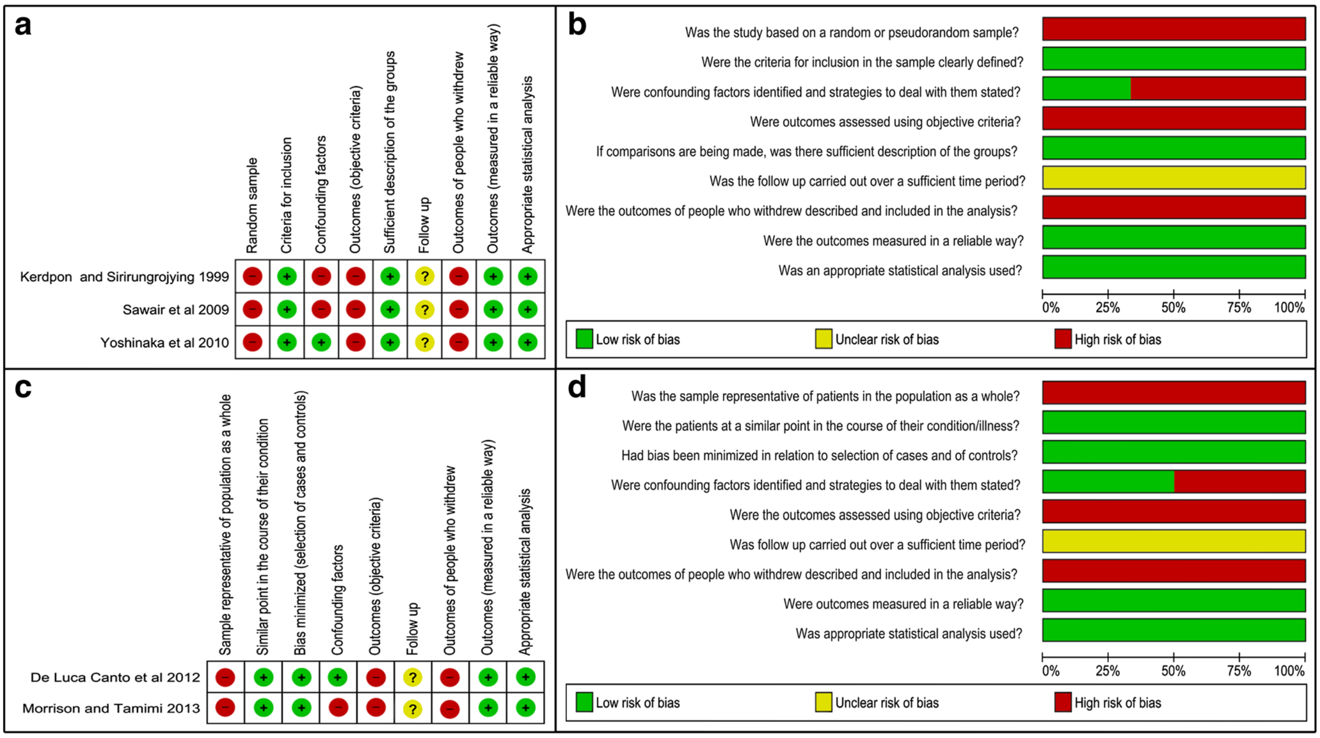

Fig. 2 Risk of bias for cross-sectional (**a**) and case-control (**c**) studies, assessed by Meta Analysis of Statistics Assessment and Review Instrument (MAStARI) critical appraisal tools. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included

"history of parafunctional habits" while De Luca Canto [12] used questions with the diagnostic criteria proposed by American Academy of Sleep Medicine [34]. Both reported similar OR (OR = 2.70; 95%CI = (1.47–4.49) and OR = 2.40; 95%CI = (1.39–4.13), respectively). However, when adjusted for self-perception only, De Luca Canto [12] found no significant association.

For TP, one of the included studies [30] found no significant association (OR = 1.12; 95%CI = (0.65–1.91)), while in contrast, other study [31] found a positive association (OR = 3.84; 95%CI = (2.13–6.90)).

Confidence in cumulative evidence

The overall quality of evidence identified using GRADE's summary of findings table was low to very low due to high risk of bias, methodological heterogeneity (inconsistency), indirectness, and imprecision, noted within the included studies, mainly for Self-report of teeth grinding and/or clenching. The summary of findings table can be found on Table 3.

Discussion

The diagnosis of bruxism is a challenge. Due to the lack of consensus in the literature, Lobbezoo et al. [19] proposed a diagnostic grading system. This grading system suggested that "possible" SB should be based on self-report, by means of questionnaires and/or the anamnestic part of a clinical examination. "Probable" SB should be based on self-report and the inspection part of a clinical examination. "Definite" SB should be based on self-report, a clinical examination, and a polysomnographic recording, likely along with audio/video recordings [19].

This SR investigated the available evidence on the association between signs and/or symptoms of bruxism and the presence of tori. Findings indicate a positive association between *abnormal tooth wear* and the tori [6, 11, 12]; while the symptom *self-report of teeth grinding and/or clenching* presented contradictory results [30, 31]. Based on the current available literature and on the eligibility criteria established for this SR, the association of tori with other signs and symptoms of bruxism could not be assessed.

It is important to emphasize that this SR is focused on signs and symptoms of bruxism, and not AB or SB as diagnosed conditions or behaviors [35, 36]. Most of the studies in the literature did not associate tori with SB correctly; therefore, it was deemed adequate to investigate the possible association of tori with the signs and symptoms of bruxism, getting deeper into the clinical correlates of bruxism.

Results from this SR showed that the presence of *abnormal tooth wear* may increase the odds for tori, mainly for TM, in line with suggestions from studies, found a positive association between abnormal tooth wear and TM [9, 13]. Variables such as the greater size of tori and stronger bite force have also a positive association with abnormal tooth wear [12, 37–39]. In addition to that, studies have shown that tori was associated with increased electromyographic activity of masticatory muscles [40], and its frequency among dentulous patients was higher than it is among edentulous ones [4, 8, 15, 41].

Kerdpon and Sirirungrojying [6] stated that TM might not be a consistent indicator of bruxism, as there were patients with TM who did not had bruxism. It is relevant to notice that there was no distinction of AB or SB held in his study [6], and it was not clear if all subjects in the group "with parafunction" had abnormal tooth wear or other stated signs (mobility of teeth that were periodontally compromised, and fractures of teeth and/or restorations). Historically, abnormal tooth wear is the most observable clinical sign of bruxism [42–44], even though, it does not represent a definitive criterion for bruxism diagnosis [45]. The evaluation of tooth wear for predicting actual bruxism activity and its severity is still controversial. Also, studies had already showed that bite force of subjects with SB and healthy controls are similar [46, 47]. Tooth wear is a multifactorial condition and cumulative record of both functional and parafunctional wear, and it may be related to other conditions such as chemical erosion, age, malocclusion, and dental characteristics [20, 42, 44, 48, 49].

None of the included studies of this SR divided participants into subgroups based on the purported etiology of tooth wear (e.g., mechanical or chemical wear). It should be noted that just recently, an evaluation system for tooth wear was proposed (tooth wear evaluation system-TWES) [50]. Teeth grinding or clenching might be as well associated with the presence of tori. Forces exerted on the lingual or palatal bone during excursive movements presented in teeth grinding could trigger a cascade of molecular events leading to tori formation. A possible pathophysiological hypothesis is that grinding could increase the loading on teeth, transferring the force to the bone, remodeling it over time, and strengthening it to resist that loading [16]. Both the maxilla and mandible undergo similar bone remodeling during forces exerted on teeth grinding and/or clenching and occlusal overload [17]. The excursive teeth grinding stresses in the mandible arch are concentrated in the ridge area, where TM is usually formed. A study [51] described that a square shaped mandible also favors the formation of TM in subjects with excursive mandibular parafunctional activity. However, the published results [51] have also indicated that teeth grinding activity did not influence the mandibular form (i.e., angulation and shape) significantly. This could possibly indicate that the mandibular anatomy and parafunctional activity such as *teeth grinding and/or clenching* act as synergistic independent predisposing factors, associated with greater risk of TM formation. Nevertheless, none of the included articles did mention, nor studied this possible association. [51].

Table 3 GRADE's summary of finding table using Gradepro software

Is there an association between any specific signs and symptoms of bruxism and the presence of tori?

To summarize the available evidence, based in our described eligibility criteria, five studies were selected and analyzed. Data extracted from case-control and cross-sectional studies were assessed. A qualitative descriptive analysis of the results was performed; meta-analysis was not performed due to high methodological heterogeneity.

Outcomes	Impact	№ of participants (studies)	Quality of the evidence (GRADE)
Abnormal tooth wear, dental wear or shiny occlusal/incisal wear facets	Based on the analyzed included studies, it seems that patients with *abnormal tooth wear* have increased odds of presenting both tori, mainly TM.	142 cases 58 controls 164/exposed 90/unexposed (4 observational studies)	⊕ ⊕ ○○ Low[a,b,c]
Self-report of teeth grinding and/or clenching	Based on the analyzed included studies, the presence of "*self-reported teeth grinding and/or clenching*" presented contradictory results for both TM and TP. There is not enough high-quality evidence to fully support the association.	76 cases 24 controls 73/exposed 294/unexposed (3 observational studies)	⊕○○○ Very low[a,b,d]

The risk in the intervention group (and its 95% confidence interval) is based on the assumed risk in the comparison group and the relative effect of the intervention (and its 95% CI).

CI confidence interval, *TM* torus mandibularis, *TP* torus palatinus

GRADE Working Group grades of evidence

High quality: We are very confident that the true effect lies close to that of the estimate of the effect

Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different

Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect

Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

[a] Most of studies had high risk of bias, assessed with MAStARI methodological criteria (−1)

[b] Methodological heterogeneity across studies (cross-sectional and case-control) (−1)

[c] The effect was very large in most studies (OR >5.0) (+2)

[d] Questionnaires and anamnesis applied were very different (−2)

Other systemic and occlusal factors potentially playing a role in tori etiology must be investigated in the future to get a deeper insight into the association between signs and/or symptoms of bruxism and the presence of tori. Moreover, the complex interactions between genetic, anatomic, and environmental factors might be important for the multifactorial genesis of tori, which may vary depending on the population studied. Signs and symptoms of bruxism and its correct classification as AB, SB, or an isolated objective sign or subjective symptom, should be taken into account and properly assessed.

Limitations

Even if questionnaires and clinical assessment are widely used tools for large sample researches, most of the included studies did not used previously validated objective criteria. Questionnaires were very heterogeneous. Different terms like "parafunction habits history," "presence of parafunction," "self-report, self-awareness or self-perception," "bruxism," or "teeth grinding or clenching" were used indiscriminately, without an established concept. Therefore, their qualities were considerably downgraded. Caution needs to be exercised when extrapolating these results. As GRADE Working Group advises, there is a possibility that the actual effects could be substantially different if higher evidence becomes available. In addition, cause-and-effect relationship could not be demonstrated considering the available literature.

Conclusion

Based on available evidence, it seems that *tori are associated* with presence of abnormal tooth wear. Patients with abnormal tooth wear might have greater chance of present tori, mainly TM. Although TP was also positively associated, the available evidence is weaker than for TM.

There is *not enough high-quality evidence* to fully support the hypothesis that teeth grinding and/or clenching, as identified by self-awareness or anamnesis, are associated with tori.

Other signs and symptoms could not be assessed due to the lack of adequate information in the studies.

It is necessary to emphasize that the quality of the literature on these subjects are still poor. Future carefully designed studies are encouraged.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

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Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed consent For this type of study, formal consent is not required.

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