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Review

The association between occlusal factors and noncarious cervical lesions: A systematic review

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ABSTRACT

Objectives: This study aimed to systematically review the scientific evidence for the association between noncarious cervical lesions (NCCL) and occlusal risk factors (ORF) [occlusal interferences in excursive movements; occlusal force; premature contacts; type of guidance; skid of centric occlusion to maximum intercuspidation] in adults.

Sources: Pubmed, Web of Science, Cochrane, Lilacs, Clinical Trials, National Research Register and National Institute for Health were searched.

Study selection: From 1082 potentially eligible studies, 106 were selected for full text analysis. Two independent reviewers (Kappa = 0.8; $p < 0.001$) selected the studies, abstracted information and assessed quality based on standardised scales. Six cross-sectional, two case-controls and one clinical trial were included. Several occlusal variables were analysed among the studies, but there was no standardisation of the units used in the analysis of occlusal factors. The majority of studies did not find significant associations between NCCL and ORF. Three studies found associations between NCCL and some variables (occlusal contact area, right canine guidance, premature contacts in centric relation and working side) ($p < 0.05$). The methodological quality varied across studies, and there was high heterogeneity among them.

Conclusion: Current scientific evidence does not support an association between ORF and NCCL. Further prospective studies with standardised methods are vital to strengthen the evidence.

Clinical significance: Understanding the risk factors for NCCL is important to control the causes and to help the dentist choose the best approach for the patient. The evidence does not support intervention to alter some occlusal factors for the prevention or control of the progression of NCCL.

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1. Introduction

Noncarious cervical lesions (NCCL) involve the loss of hard tissue from the cervical areas of teeth through processes unrelated to caries.[1,2] The prevalence of NCCL has been reported to vary between 5–85%.[3] This large variation in the prevalence can be attributed to the different ages and sexes of the participants in the studied populations and the diverse

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criteria used to distinguish lesions caused by one precise aetiologic factor.[3,4] The aetiology of NCCL continues to be discussed in the literature. While the various possible causes and their degree of involvement may be controversial, there is overwhelming evidence that the cause of NCCL is multifactorial.[5,6] Noncarious loss of tooth structure can result from different mechanisms, such as erosion(dental manifestations of chemical or electrochemical degradation) and friction, including attrition (endogenous mechanical wear) and abrasion (exogenous mechanical wear).[7] These processes of tooth reduction, however, do not explain the development of wedge-shaped defects or subgingival lesions.[8] Lee and Eakle[9] further developed a proposal that was first discussed by Lehman and Meyer,[10] which stated that stress may play a role in the aetiology of NCCL.[9] Grippo[11] later called these lesions ''abfractions,'' which literally means a ''breaking away'' and is derived from the Latin words *ab* (away) and *fractio* (breaking). Engineering studies support the ''abfraction theory'' as tensile stress resulting from oblique occlusal forces may cause disruption of the bonds between the hydroxyapatite crystals and the separation of the enamel from the dentine. Compressive forces acting together with tensile stresses are also considered to cause microfacture, fatigue, flexure, and deformation of the tooth structure.[12,13] In addition, as enamel is quite thin and the Hunter-Schreger Band (HSB) packing densities are very low at the cervical regions of tooth crown, abfractions may be passively facilitated by HSB patterns.[14]

Patients should be informed of the possible aetiologies and implications of the presence of lesions, along with the methods of prevention, treatment alternatives, and expected prognosis.[6] Understanding the risk factors of NCCL is important in controlling the causes and to assist the dentist in choosing the best approach for the patient. The available evidence that supports the association between occlusal stress and cervical wear is derived from finite element analysis and laboratory studies, with little clinical data to provide confirmation. Recently, a review evaluated the association between occlusion and NCCL.[15] However, an additional analysis that involves multiple electronic databases, a broader search strategy and a study quality appraisal based on standardised scales is recommended. Therefore, as the sufficient evaluation of this topic is lacking, this study aimed to systematically search for scientific evidence on the association between occlusal factors (occlusal interference in excursive movements; occlusal force; premature contacts; type of guidance; and skid of centric occlusion to maximum intercuspidation)and NCCL in adults.

2. Materials and methods

2.1. *Selection of articles*

This systematic review included cross-sectional studies, case-control studies, cohort studies and clinical trials conducted in adult humans that evaluated the presence of NCCL (outcome) associated with occlusal risk factors (exposure). Occlusal risk factors included any type of occlusal interference in excursive movements; occlusal force; premature contacts; type of guidance; and presence of skid of centric occlusion to maximum intercuspidation (CO-MI skid). In October and November 2010, two reviewers (AGS and CCM) searched seven databases (PubMed, Web of Science, Cochrane, Lilacs, Clinical Trials, National Research Register – UK, and the National Institutes of Health) without restrictions on language or the date of publication. The literature search was updated in May 2012. The following search strategy was used in PubMed, Web of Science and Cochrane: ((non-carious cervical lesions OR noncarious cervical lesions OR non-carious cervical lesions OR tooth wear [Mesh] OR tooth abrasion [Mesh] OR dental abrasion OR cervical abrasion OR tooth erosion [Mesh] OR dental erosion OR tooth attrition [Mesh] OR dental attrition OR dental abfraction OR abfraction* OR abfraction lesions OR tooth abfraction) AND (dental occlusion [Mesh] OR bite force [Mesh] OR dental stress analysis [Mesh] OR occlusion factors OR premature contacts OR occlusal load* OR occlusal contacts OR risk factors [Mesh] OR pathology [Mesh]) NOT (''animals''[Mesh] NOT ''humans''[Mesh])). The Cochrane Library included: the Cochrane Database for Systematic Reviews, the Database of Abstracts of Reviews of Effectiveness, the Cochrane Controlled Trials Register and the Cochrane Review Methodology Database. Lilacs, Clinical Trials, National Research Register (UK) and the National Institutes of Health were searched using the following combined keywords: noncarious cervical lesions, dental occlusion, occlusal contacts, bite force, dental stress analysis, risk factors, tooth wear, abfraction lesions, dental abfraction, tooth abfraction, tooth abrasion, dental abrasion, tooth erosion, dental erosion, tooth attrition, and dental attrition. The online search retrieved 925 references from PubMed, 73 from Web of Science, 49 from Cochrane and 201 from other sources (Fig. 1). After the duplicate references were removed, a total of 1082 studies were entered in Reference Manager® (Reference Manager, Thomson Reuters, version 12.0.3). A list provided by the Reference Manager was analysed, and articles were selected based on abstracts and/or titles. Two reviewers (A.G.S. and C.C.M.) were calibrated on the application of the inclusion and exclusion criteria. As a calibration exercise, the reviewers thoroughly discussed the criteria and applied them to a sample of 20% of the retrieved studies. This exercise was repeated until an excellent agreement was obtained (kappa = 0.81). The inclusion criteria were: cross-sectional studies, case-control studies, cohort studies and clinical trials related to NCCL; reviews related to NCCL; and references without abstracts but presenting titles related to NCCL. Reviews related to NCCL were initially evaluated to allow for a manual search on their reference lists. However, review articles were not included. Among the studies that were not selected, classification proceeded as follows: reviews unrelated to NCCL; non-human studies; case reports or case series; surveys; different outcomes than NCCL; references without abstracts but presenting titles unrelated to NCCL; in vitro studies (laboratorial, extracted teeth, fossils, skulls, finite element analysis); and studies that reported on restorative materials, treatments in humans, diagnostic methods of NCCL or wear indexes (for a list of excluded abstracts and/or titles, see Appendix 1).

The reviewers independently applied the criteria for the selection of studies, and disagreements were resolved by consensus. A total of 976 studies were excluded, and 106 were selected for the full text reading.

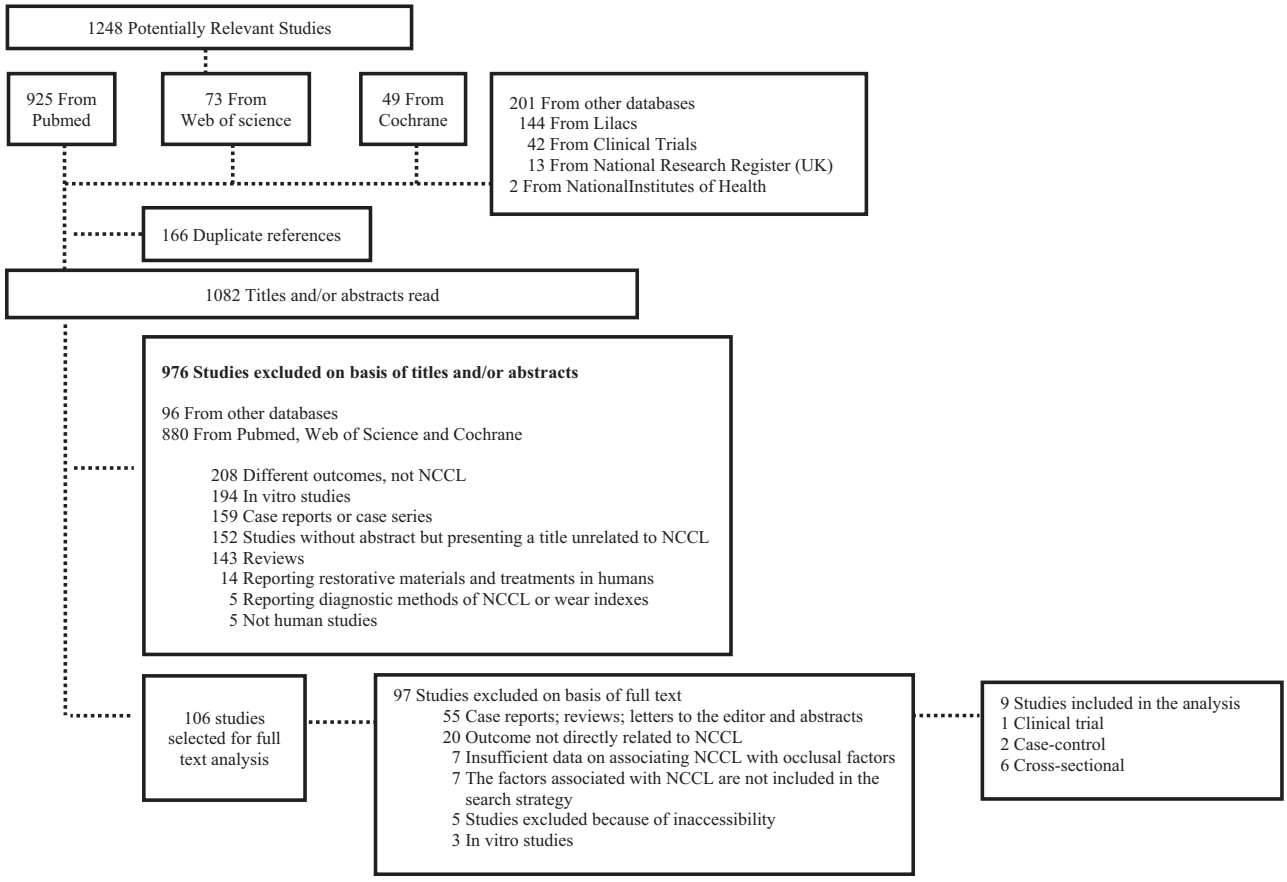

Fig. 1 – Flow diagram showing the process of selecting published articles.

Among the 106 selected studies, 97 were excluded, as they contained case reports; reviews; letters to the editor; abstracts; outcomes not directly related to NCCL; insufficient data to verify the association of NCCL with occlusal factors (for example, data on prevalence only); factors associated with NCCL that were not included in the search strategy; inaccessibility of the full article; and in vitro studies (for a list of excluded full text studies, see Appendix 2).

2.2. *Data extraction*

Descriptive data on clinical and methodological aspects were independently extracted by two reviewers (A.G.S. and C.C.M.), and questions were resolved by consensus. Eventually, nine studies[5,16–23] that exhibited statistical analysis for the association between NCCL and occlusal factors were included in the systematic review. During the process of data extraction, when necessary, the first author was contacted to elicit further information (data from statistical analysis). Only one author[24] replied and justified the lack of a presentation of a risk measure, as the data did not support such a calculation.

2.3. *Methodological quality assessment*

Quality assessment was performed by two independent reviewers using a modification of the Newcastle–Ottawa Scale[25] for case control studies, awarding stars to the eligible categories (selection, comparability and exposure/outcome) for each article. The quality of the clinical trial was rated using the PEDro scale.[26] Disagreements were resolved by discussion and consensus between reviewers.

2.4. *Data synthesis*

The pooling of data was based on the study design, the population characteristics and the unit of analysis (subject or tooth). As the studies presented great methodological heterogeneity and differences in reporting the results, a meta-analysis was not possible. A narrative synthesis of the data was conducted.

3. Results

3.1. *Study design, setting and population characteristics*

The selected studies included six cross-sectional studies,[16,18–22] two case-control studies,[5,17] and one clinical trial,[23] carried out in the USA,[5,16,18] in Europe,[19,20,23] and Asia.[17,21,22] Five studies[5,16,17,20,23] used a comparative group that was classified as a control group. Five studies recruited subjects from university clinics,[5,17,18,20,21] two studies from military bases,[16,22] one study from a private practice[23] and one from a public health system.[19] Patients' ages ranged from 16 to 80

Table 1 – Studies included in the review regarding the association between NCCL and occlusal factors.

Authors; year; location of study	Design	Setting	Sample size analysed	Subjects; age	NCCL analysis	Occlusal factors identified (exposure)	Unit of analysis	Univariate or multivariate regression analysis	Occlusal factors as cause of association	Quality assessment score
Piotrowski et al. (2001) EUA	Cross-sectional	Military Base	32 subjects (103 case teeth and 63 control teeth)	38–80	Clinical dental examination	Evidence of prematurity in centric occlusion, as well as interference in balancing, working or protrusive excursive movements	Teeth	Univariate	Occlusal contacts ($p^{*} = 0.41$) between case and control teeth. No significant association between any variable and NCCL	4(10)
Estafan et al. (2005) EUA	Cross-sectional	University Clinic	299 casts made from subjects	28.9 mean	Casts Analysis	Occlusal interferences (protrusive, working and non-working excursive). Occlusal guidance scheme (anterior guidance, canine guidance, group function)	Subject	Univariate	There was no correlation ($R^{**} < 0.2$) between NCCL and the parameters examined	6(10)
Bernhardt et al. (2006) Germany	Cross-sectional	Public Health System	2707 subjects (54,204 teeth)	20–59	Clinical dental examination	Dynamic occlusal (protrusion; laterotrusion to the left and to the right)	Teeth	Univariate and multivariate	There was no association between abfraction protrusion contacts ($OR^{***} = 0.95$), laterotrusion contacts to the left ($OR^{***} = 1.34$) and to the right ($OR^{***} = 0.97$)	9(10)
Ommerborn et al. (2007) Germany	Cross-sectional	University Clinic	91 subjects (58 case and 33 control)	20–39	Clinical dental examination	Occlusal guidance scheme (anterior guidance, canine guidance, group function). Slide from *n* CO to MI, and the length of the slide	Subject	Univariate	R Canine guidance; ($OR^{***} = 0.61$, $p^{*} = 0.603$). L Canine guidance; ($OR^{***} = 0.84$, $p^{*} = 0.839$). R Anterior guidance; ($OR^{***} = 1.85$, $p^{*} = 0.251$). L Anterior guidance; ($OR^{***} = 1.82$, $p^{*} = 0.231$). L Anterior guidance; ($OR^{***} = 1.82$, $p^{*} = 0.231$). R Group function; ($OR^{***} = 1.53$, $p^{*} = 0.393$). L Group function; ($OR^{***} = 1.64$, $p^{*} = 0.290$). CO – MI slide; ($OR^{***} = 0.93$, $p^{*} = 0.881$). Mean length of slide; ($p^{*} = 0.233$). Existence of the slide and guidance seems to be of minor importance in the development of NCCL.	4(10)
Smith, Marchan and Rafeek, (2008) Indies	Cross-sectional	University Clinic	156 subjects	16–73	Clinical dental examination	Type of guidance (canine or group function)	Subject	Univariate	Weak association between presence of NCCL and right group function ($OR^{***} = 1.3$/IC = 0.6, 2.9) and left group function ($OR^{***} = 1.3$/IC = 0.6, 2.9) and left group function ($OR^{***} = 1.7$/IC = 0.8, 3.8)	5(10)

Takehara et al. (2008) Japan	Cross-sectional	Okadama base of the ground self-defence force	159 subjects	20–50	Clinical dental examination	Occlusal force Occlusal contact area Occlusal pressure	Subject	Univariate and multivariate	Occlusal contact area (OR*** = 4.15, p^* = 0.038) was associated with the presence of NCCL. No significant association between NCCL and these parameters examined [Occlusal pressure (OR*** = 2.06, p^* = 0.127) and Occlusal force (OR*** = 0.99 and p^* = 0.990)]	7(10)
Bader et al. (1996) EUA	Case-control	University clinic	264 subjects (137 case and 127 control subjects) (618 case teeth and 3276 control teeth)	Above of 18 years	Clinical dental examination	Functional occlusion as canine guidance or group function (functional, non-functional and protrusive contacts). Slide from CO to MI	Tooth-level and Subject-level	Univariate and multivariate	R canine guidance (OR*** = 3.16, IC = 1.07, 9.28) was associated with the presence of NCCL. No significant association between non-functional contact (OR*** = 0.53, IC = 0.29, 0.98) and NCCL	7(10)
Madani and Ahmadian-Yazdi, (2005) Iran	Case-control	University clinic	77 subjects (167 case teeth and 167 control teeth)	Not related	Clinical dental examination	Type of premature contacts (Central relation, working, balancing, protrusion)	Teeth	Univariate	Significant difference between NCCL and premature contacts (p^* = 0.0169). In Centric relation (p^* = 0.0222) and in Working side (p^* = 0.0022). No significant difference in balancing (p^* = 0.7652) and protrusion (p^* = 0.3232)	4(10)
Wood, Kassir and Brunton (2009) UK	Clinical Trial	Private Practice	31 subjects and 62 teeth selected	18–75	The size of the lesions was measured using stereomicroscopic analysis of the sectioned epoxy resin dies.	Occlusal contacts in teeth (group function) during lateral excursive movements	Teeth	Univariate	No statistically significant difference in rate of lesion progression for teeth that had been adjusted and those that had not at 6, 18 and 30 months (p^* = 0.510, p^* = 0.682, and p^* = 0.669, respectively)	7(10)

IC, confidence interval; R, right; L, left; NCCL, noncarious cervical lesions; CO, centric occlusion; MI, maximum intercuspidation.
* p value.
** Spearman Correlation Index.
*** Odds ratio.

years old. A convenience sample was selected by most studies.[5,17,18,20–22] One was a population-based cross-sectional study from which a random sample was drawn, stratified by gender and age.[19] A randomised controlled trial selected a convenience sample, but the treatment was randomly allocated using closed envelopes.[23] No study clarified the strategy used for sample size calculation, except for the population-based epidemiological study that included 2707 subjects with more than four natural teeth from a gross sample of 6267 subjects.[19] The included studies totalled 3816 subjects and 58,660 teeth. Some studies[16,18,21] did not clearly report the sample inclusion and exclusion criteria. On the other hand, other studies[5,17,19,20,22,23] reported exclusion and/or inclusion criteria related to subjects or teeth, such as: the minimal number of teeth in the mouth; minimal age; presence of removable partial prosthesis; temporomandibular disorders; pathological disorders; use of controlled medication; severe periodontal disease; teeth without Class V restorations; teeth with wedge-shaped NCCL; dental mobility; presence of noncarious cervical lesions without caries; cervical lesions that did not require operative intervention; subjects with poor oral hygiene; and teeth with noncarious cervical lesions that presented contact in group function during lateral excursive movements, among others.

3.2. *Evaluation of NCCL*

Most studies evaluated NCCL by means of a clinical dental examination[5,16–22]; only one study[18] used clinical evaluation to check the data found in cast models. In some studies, cast models were built to measure both the lesion depth and size[16] or to assess the presence or absence and severity of NCCL.[18] One study built epoxy-resin replicas for the measurement of NCCL during the follow-up period (6, 18 and 30 months).[23] All the selected studies evaluated all the teeth groups (molars, pre-molars, canines and incisors),[5,16–22] but one study analysed both molar and pre-molar teeth.[23] Only one study used the Tooth Wear Index (TWI) in its analysis.[22]

3.3. *Occlusal factors investigated*

Table 1 presents the occlusal risk factors for NCCL investigated: occlusal interferences in excursive movements; occlusal force; premature contacts; type of guidance; and the skid of centric occlusion to maximum inter-cuspidation. All studies but one used clinical methods to verify the occlusal factors. Only one study[22] used quantitative methods to evaluate occlusal force (N), the occlusal contact area (mm^2), and the occlusal pressure (MPa), which were measured using a pressure-detecting sheet (Dental Prescale® 50H Type R, Fuji Film Co., Tokyo, Japan) and a measuring device (Occluzer, Fuji Film Dental Occlusion Pressuregraph FPD 705, Fuji Film Co.). One of the studies[18] used casts mounted in a semi-adjustable articulator to investigate occlusal factors, and subsequently checked the findings by an in-mouth clinical analysis.

3.4. *Unit of analysis*

The studies used teeth,[16,17,19,23] subjects,[18,20–22] or both[5] as units of analysis to investigate the association between occlusal factors and NCCL. Six studies performed univariate analyses,[16–18,20,21,23] and three studies[5,19,22] performed both univariate and multivariate regression analyses. The epidemiologic study[19] could not evaluate the occlusal factors in the multivariate model. Otherwise, in the case-control study,[5] the occlusal factors were analysed in the multivariate model, with the tooth considered to be the unit of analysis.

3.5. *Occlusal factors as cause of association*

The occlusal factors identified as causes of an association with the presence of NCCL were: occlusal contact area (OR = 4.15/p = 0.038);[22] right canine guidance (OR = 3.16/IC = 1.07, 9.28);[5] and premature contacts in centric relation (p = 0.0222) and the working side (p = 0.0022).[17] The results of non-association can be observed in Table 1. Differences in the presentation of effect measures were observed, such as the odds ratio (OR), p value (p), confidence interval (IC), and Spearman correlation index (R).

3.6. *Methodological quality assessment*

The quality of the studies ranged from four to nine in ten-point scales (Table 1). Three studies received the lowest score,[16,17,20] and only one was rated with nine points.[19] The clinical trial was rated as seven on a ten-point scale.[23]

4. Discussion

This systematic review involved the search of multiple electronic databases, with no restrictions regarding language or year of publication. In the end, 106 studies were selected for full text analysis and nine studies were included in the quality analysis. The quality of studies ranged from four to nine on a ten-point scale. It was difficult to assess the studies due to their heterogeneity and differences in methods, designs, and considered occlusal factors. The greatest difficulty was that the articles did not follow a classic epidemiologic study design, such as case-controls and clinical trials. We will discuss quality assessment for cross-sectional and case-control studies together and separately for the clinical trial. Although investigators usually described the setting in which the cross-sectional and case-control studies took place, a detailed description of the eligibility criteria and the methods of participant selection were often not adequately reported. This may have affected the external validity, as only the study by Bernhardt et al. (2006)[19] was representative of Pomerania, and the remaining studies contained selected convenience samples.[5,16–18,20–22]

The variables considered for the studies, including risk factors and outcome, were well defined by the authors. However, the NCCL diagnosis criteria were heterogeneous, and only one study used a validated index to evaluate cervical tooth wear (TWI).[22] Six studies reported a calibration exercise to evaluate NCCL,[5,18–22] but only two referred to inter- and intra-examiner agreement and Kappa analysis.[5,19] No study repeated measures in the same individuals to validate data. Measurement errors of variables may have produced spurious relationships or avoided the detection of significant

associations. Despite its importance, some studies failed to report rates of non-respondent or missing patients.[16,17,20–22] Others studies reported missing data from the general sample but they did not discuss how this missing data affected the representation of the study population.[5,18,19]

Some studies attempted to identify the association of other variables with NCCL, such as gingival recession, buffering capacity and flow rate of saliva, bruxism, temporomandibular dysfunction, headache, brushing, acid diet, dentine sensitivity, and reflux, among others. However, only three studies controlled for confounders using logistic regression and described how the variables were chosen and included in the final model.[5,19,22]

The clinical trial[23] scored seven on the ten-point PEDro scale.[26] This was a controlled trial that included 39 subjects who had two NCCLs in maxillary premolars or molars in group function during lateral excursive movements of the mandible. It was a convenience sample drawn from patients who attended a private practice. One tooth was randomly selected to have the excursive occlusal contacts reduced and the other was the control. The teeth allocation was concealed. The operator was not blinded, and the assessor who measured the outcome could not identify the tooth that was adjusted. It was concluded that reducing the occlusal load in lateral excursion did not decrease the rate of progression of NCCL. However, the clinical trial failed to control for confounders such as brushing, diet and bruxism.[23]

Although it was not a classical case-control study, comparison groups (case and control) were used in a multivariate model that considered the tooth as the unit of analysis.[5] It was found a significant association between right canine guidance and NCCL.[5] The other tooth-paired case-control study[17]found a significant association between NCCL and premature contacts in centric relation and at the working side. The advantage of this study design was the direct assignment of tooth-related characteristics to the occurrence of cervical lesions.

From the nine articles selected, only three (one cross-sectional[22] and two case-control studies[5,17]) stated the association between occlusal factors and NCCL, although even these differed in their identified occlusion factors. There was a significant association between NCCL and occlusal contact area (OR = 4.15/p = 0.038),[22] right canine guidance (OR = 3.16/IC = 1.07, 9.28),[5] premature contacts in centric relation (p = 0.0222) and working side (p = 0.0022).[17]

Univariate unconditional logistic regression analysis showed that some occlusal factors, such as occlusal contact area (mm^2), occlusal force (N) and occlusal pressure (MPa), were significantly associated with the presence of NCCL.[22] However, on the final multivariate model, only the occlusal contact area (>23.0 mm^2, OR = 4.15) was significantly related to the presence of NCCL, supporting the results of previous in vitro studies that indicated a significant role of occlusal factors in NCCL formation.[22] Otherwise, the results must be interpreted carefully, as these three measurements were collected in a short period of time and cannot represent 24-h occlusal stress.[22]

Several exposure factors that represented each of the three putative causal mechanisms (oral hygiene factors, occlusal factors and dietary factors) were included and adjusted the final main-effects models at the tooth-level analysis.[5] Only one factor related to occlusion (right canine guidance) remained as a risk factor that was significantly associated with NCCL, but it presented a wide confidence interval. A protective effect was attributed to the presence of a balancing contact. This was not a logical association direction, which may be the result of overfitting the model or the post hoc determination of exposure.[5]

According to Madani and Ahmadian-Yazdi,[17] NCCL formation might be associated with the characteristics of the teeth on which the occlusal forces are applied and/or the types of premature contacts. In the group with NCCL, a highly significant and positive correlation was detected between the number of teeth with NCCL and the number of premature contacts in centric relation and the working side, but not in balancing and protrusion. The authors reinforced the theory that any occlusal contact that generates tensile stress on the cervical area has the possibility of creating a NCCL. However, this study did not demonstrate suitable adjusting methods for confounders, except the exclusion of lesions that were potentially caused by abrasion or erosion.

From a total of 106 studies eligible for full text analysis, only nine studies were included in this review. However, another review included 28 studies from 147 eligible studies.[15] Although both reviews stated similar objectives, there are many differences as to their data sources, search strategies, study eligibility criteria, exposure variables, study appraisal and synthesis methods.Nevertheless, they agreed about the heterogeneity of the studies design, the presence of bias, the lack of control for confounders and the inability to establish a clear association between occlusion and NCCL.

Long-term follow-up studies across various ages and controlling for confounders are needed to confirm the effect of occlusal risk factors on NCCL initiation and progression. This systematic review provides new perspectives on the development of further studies related to NCCL and associated factors, considering the possible multifactorial aetiology of NCCL.

5. Conclusions

The available scientific evidence could not confirm an association between occlusal factors and NCCL. Further prospective studies with standardised methods are vital to strengthen the evidence.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.jdent.2012.10.018

REFERENCES

1. LittleStar ML, Summitt JB. Non-carious cervical lesions: an evidenced-based approach to their diagnosis. *Texas Dental Journal* 2003;**120**(10):972–80.
2. Michael JA, Townsend GC, Greenwood LF, Kaidonis JA. Abfraction: separating fact from fiction. *Australian Dental Journal* 2009;**54**(1):2–8.
3. Rees JS, Jagger DC. Abfraction lesions: myth or reality? *Journal of Esthetic and Restorative Dentistry* 2003;**15**: 263–71.
4. Levitch LC, Bader JD, Shugars DA, Heymann HO. Non-carious cervical lesions. *Journal of Dentistry* 1994;**22**:195–207.
5. Bader JD, McClure F, Scurria MS, Shugars DA, Heymann HO. Case-control study of non-carious cervical lesions. *Community Dental Oral Epidemiology* 1996;**24**(4):286–91.
6. Mark L, LitteStar.. Non-carious cervical lesions: an evidence-based approach to their diagnosis. *Texas Dental Journal* 2003:972–80.
7. Jo G, Simring M, Schreiner S. Attrition, abrasion, corrosion and abfraction revisited: a new perspective on tooth surface lesions. *The Journal of the American Dental Association* 2004;**135**:1109–18.
8. Karl. Lyons. Aetiology of abfraction lesions. *New Zealand Dental Journal* 2001;**97**:93–8.
9. Lee WC, Eakle WS. Possible role of tensile stress in the etiology of cervical erosive lesions of teeth. *Journal of Prosthetic Dentistry* 1984;**52**:374–80.
10. Lehman ML, Meyer ML. Relationship of dental caries and stress: concentrations in teeth as revealed by photoelastic tests. *Journal of Dental Research* 1966;**45**:1706–14.
11. Grippo JO. Abfractions: a new classification of hard tissue lesions of teeth. *Journal of Esthetic Dentistry* 1991;**3**:14–9.
12. Lee HE, Lin CL, Wang CH, Cheng CH, Chang CH. Stresses at the cervical lesion of maxillary premolar. A finite element investigation. *Journal of Dentistry* 2002;**30**:283–90.
13. Rees JS. The biomechanics of abfractions. *Proceedings of the Institution of Mechanical Engineers Part H Journal of Engineering in Medicine* 2006;**220**:69–80.
14. Lynch CD, O'Sullivan VR, Dockery P, McGillycuddy CT, Sloan AJ. Hunter-Schereger band patterns in human tooth enamel. *Journal of Anatomy* 2010;**217**:106–15.
15. Senna P, Del BelCury A, Rösing C. Non-carious cervical lesions and occlusion: a systematic review of clinic studies. *Journal of Oral Rehabilitation* 2012;**39**:450–62.
16. Piotrowski BT, Gillette WB, Hancock EB. Examining the prevalence and characteristics of abfractionlike cervical lesions in a population of U.S. veterans. *The Journal of the American Dental Association* 2001;**132**(12): 1694–701.
17. Madani AO, Ahmadian-Yazdi A. An investigation into the relationship between noncarious cervical lesions and premature contacts. *Cranio* 2005;**23**(1):10–5.
18. Estafan A, Furnari PC, Goldstein G, Hittelman EL. In vivo correlation of noncarious cervical lesions and occlusal wear. *Journal of Prosthetic Dentistry* 2005;**93**(3):221–6.
19. Bernhardt O, Gesch D, Schwahn C, Mack F, Meyer G, John U, *et al*. Epidemiological evaluation of the multifactorial aetiology of abfractions. *Journal of Oral Rehabilitation* 2006;**33**(1):17–25.
20. Ommerborn MA, Schneider C, Giraki M, Schafer R, Singh P, Franz M, *et al*. In vivo evaluation of noncarious cervical lesions in sleep bruxism subjects. *Journal of Prosthetic Dentistry* 2007;**98**(2):150–8.
21. Smith WA, Marchan S, Rafeek RN. The prevalence and severity of non-carious cervical lesions in a group of patients attending a university hospital in Trinidad. *Journal of Oral Rehabilitation* 2008;**35**(2):128–34.
22. Takehara J, Takano T, Akhter R, Morita M. Correlations of noncarious cervical lesions and occlusal factors determined by using pressure-detecting sheet. *Journal of Dentistry* 2008;**36**(10):774–9.
23. Wood ID, Kassir AS, Brunton PA. Effect of lateral excursive movements on the progression of abfraction lesions. *Operative Dentistry* 2009;**34**(3):273–9.
24. Reyes E, Hildebolt C, Langenwalter E, Miley D. Abfractions and attachment loss in teeth with premature contacts in centric relation: clinical observations. *Journal of Periodontology* 2009;**80**(12):1955–62.
25. Wells GA, Shea B, O'Connell D, et al. The Newcastle–Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses. www.ohri.ca/programs/clinical_epidemiology/oxford.htm.
26. Maher CG, Sherrington C, Herbert RD, Moseley AM. Reability of the PEDro scale for rating quality of randomized controlled trial. *Physical Therapy* 2003;**83**(8):713–21.