DANIELA NAVARRO RIBEIRO TEIXEIRA

PREVALÊNCIA DE LESÕES CERVICAIS NÃO CARIOSAS E FATORES DE RISCO ASSOCIADOS – REVISÕES SISTEMÁTICAS DA LITERATURA E ANÁLISE POR ELEMENTOS FINITOS

PREVALENCE OF NONCARIOUS CERVICAL LESIONS AND ASSOCIATED RISK FACTORS – SYSTEMATIC REVIEWS AND FINIT ELEMENT ANALYSIS

Tese apresentada à Faculdade de Odontologia da Universidade Federal de Uberlândia, para obtenção do título de doutora em Odontologia na Área de Clínica Odontológica Integrada.

Uberlândia, 2020

DANIELA NAVARRO RIBEIRO TEIXEIRA

PREVALÊNCIA DE LESÕES CERVICAIS NÃO CARIOSAS E FATORES DE RISCO ASSOCIADOS – REVISÕES SISTEMÁTICAS DA LITERATURA E ANÁLISE POR ELEMENTOS FINITOS

PREVALENCE OF NONCARIOUS CERVICAL LESIONS AND ASSOCIATED RISK FACTORS – SYSTEMATIC REVIEWS AND FINIT ELEMENT ANALYSIS

Tese apresentada à Faculdade de Odontologia da Universidade Federal de Uberlândia, para obtenção do título de doutora em Odontologia na Área de Clínica Odontológica Integrada.

Orientadora: Profa. Dra. Priscilla Barbosa Ferreira Soares

Banca examinadora:
Profa. Dra. Priscilla Barbosa Ferreira Soares
Prof. Dr. Paulo Vinicius Soares
Prof. Dr. Alexandre Coelho Machado
Profa. Dra. Ana Cecília Corrêa Aranha
Prof. Dr. Mauro Pedrini Santamaria

Uberlândia, 2020

Ficha Catalográfica Online do Sistema de Bibliotecas da UFU
com dados informados pelo(a) próprio(a) autor(a).

T266
2020

Teixeira, Daniela Navarro Ribeiro, 1993-
PREVALÊNCIA DE LESÕES CERVICAIS NÃO CARIOSAS E FATORES DE RISCO ASSOCIADOS - REVISÕES SISTEMÁTICAS DA LITERATURA E ANÁLISE POR ELEMENTOS FINITOS [recurso eletrônico] / Daniela Navarro Ribeiro Teixeira. - 2020.

Orientador: Priscilla Barbosa Ferreira Soares.
Tese (Doutorado) - Universidade Federal de Uberlândia, Pós-graduação em Odontologia.
Modo de acesso: Internet.
Disponível em: http://doi.org/10.14393/ufu.te.2020.767
Inclui bibliografia.

1. Odontologia. I. Soares, Priscilla Barbosa Ferreira,1974-, (Orient.). II. Universidade Federal de Uberlândia. Pós-graduação em Odontologia. III. Título.

CDU: 616.314

Bibliotecários responsáveis pela estrutura de acordo com o AACR2:

Gizele Cristine Nunes do Couto - CRB6/2091

UNIVERSIDADE FEDERAL DE UBERLÂNDIA
Coordenação do Programa de Pós-Graduação em Odontologia
Av. Pará, 1720, Bloco 4L, Anexo B, Sala 35 - Bairro Umuarama, Uberlândia-MG, CEP 38400-902
Telefone: (34) 3225-8115/8108 - www.ppgoufu.com - copod@umuarama.ufu.br

ATA DE DEFESA - PÓS-GRADUAÇÃO

Programa de Pós-Graduação em:	Odontologia				
Defesa de:	Doutorado, número 52, PPGODONTO				
Data:	Vinte e Cinco de Novembro de Dois Mil e Vinte	Hora de início:	14:00	Hora de encerramento:	18:56
Matrícula do Discente:	11713ODO004				
Nome do Discente:	Daniela Navarro Ribeiro Teixeira				
Título do Trabalho:	Prevalência de lesões cervicais não cariosas e fatores de risco associados – Revisões sistemáticas da literatura e análise por elementos finitos				
Área de concentração:	Clínica Odontológica Integrada				
Linha de pesquisa:	Biomecânica Aplicada à Odontologia				
Projeto de Pesquisa de vinculação:	Biomecânica Aplicada à Odontologia				

Reuniu-se em Web Conferência pela plataforma MConf - RNP, em conformidade com a PORTARIA Nº 36, DE 19 DE MARÇO DE 2020 da COORDENAÇÃO DE APERFEIÇOAMENTO DE PESSOAL DE NÍVEL SUPERIOR - CAPES, pela Universidade Federal de Uberlândia, a Banca Examinadora, designada pelo Colegiado do Programa de Pós-graduação em Odontologia, assim composta: Professores Doutores: Paulo Vinícius Soares (UFU); Alexandre Coelho Machado (UFU); Ana Cecília Correa Aranha (USP); Mauro Pedrini Satamaria (UNESP); Priscilla Barbosa Ferreira Soares (UFU) orientador(a) do(a) candidato(a).

Iniciando os trabalhos o(a) presidente da mesa, Dr(a). Priscilla Barbosa Ferreira Soares, apresentou a Comissão Examinadora e o candidato(a), agradeceu a presença do público, e concedeu ao Discente a palavra para a exposição do seu trabalho. A duração da apresentação do Discente e o tempo de arguição e resposta foram conforme as normas do Programa.

A seguir o senhor(a) presidente concedeu a palavra, pela ordem sucessivamente, aos(às) examinadores(as), que passaram a arguir o(a) candidato(a). Ultimada a arguição, que se desenvolveu dentro dos termos regimentais, a Banca, em sessão secreta, atribuiu o resultado final, considerando o(a) candidato(a):

Aprovado(a).

Esta defesa faz parte dos requisitos necessários à obtenção do título de Doutor.

O competente diploma será expedido após cumprimento dos demais requisitos, conforme as normas do Programa, a legislação pertinente e a regulamentação interna da UFU.

Nada mais havendo a tratar foram encerrados os trabalhos. Foi lavrada a presente ata que após lida e achada conforme foi assinada pela Banca Examinadora.

Documento assinado eletronicamente por **Alexandre Coelho Machado**, **Professor(a) do Ensino Básico, Técnico e Tecnológico**, em 25/11/2020, às 19:06, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do Decreto nº 8.539, de 8 de outubro de 2015.

Documento assinado eletronicamente por **Mauro Pedrine Santamaria**, **Usuário Externo**, em 25/11/2020, às 19:08, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do Decreto nº 8.539, de 8 de outubro de 2015.

Documento assinado eletronicamente por **Priscilla Barbosa Ferreira Soares**, **Professor(a) do Magistério Superior**, em 25/11/2020, às 19:10, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do Decreto nº 8.539, de 8 de outubro de 2015.

Documento assinado eletronicamente por **Ana Cecilia Corrêa Aranha**, **Usuário Externo**, em 25/11/2020, às 19:11, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do Decreto nº 8.539, de 8 de outubro de 2015.

Documento assinado eletronicamente por **Paulo Vinícius Soares**, **Professor(a) do Magistério Superior**, em 27/11/2020, às 10:59, conforme horário oficial de Brasília, com fundamento no art. 6º, § 1º, do Decreto nº 8.539, de 8 de outubro de 2015.

A autenticidade deste documento pode ser conferida no site https://www.sei.ufu.br/sei/controlador_externo.php?acao=documento_conferir&id_orgao_acesso_externo=0, informando o código verificador **2413095** e o código CRC **EFC66A0E**.

Referência: Processo nº 23117.065588/2020-97 SEI nº 2413095

DEDICATÓRIA

A cada um que,
de alguma forma,
por mais ínfima que seja,
não me deixou desistir.

AGRADECIMENTOS

A minha mãe, que segurou todas as barras comigo nesses quatro anos, mesmo sem saber. Que ria quando eu falava em desistir, me lembrando que sendo filha de quem eu sou, desistir nunca vai ser uma opção. Que ouviu Maria Bethânia comigo em um dia que tudo que eu precisava era ouvir Maria Bethânia com a minha mãe. Que foi apoio, colo, conforto, amor. É. Sempre será.

Ao meu pai, que me deu o colo que eu precisava, no momento que eu precisava. Que me lembrou que algumas decisões da minha vida cabem única e exclusivamente a mim e que ele confia em mim de olhos fechados pra isso. Que me guiou no caminho da Odontologia, quando eu nem sabia o que eu queria da vida. Tenho muito orgulho do que eu construí desde então.

A minha avó, sempre presente, sempre importante, sempre um exemplo de força e resiliência. Tê-la comigo neste momento é o melhor presente que eu poderia ganhar.

Aos meus cinco irmãos maravilhosos, que valem ouro pra mim. Em especial ao José, que foi o nosso maior presente do último ano e que fez todo mundo ficar mais pertinho, como tem que ser. Amo cada um de vocês com todo meu coração.

Aos meus tios e minhas primas, por todos os momentos deliciosos vividos juntos. A todas as cervejas, churrascos, hambúrgueres, risadas, carinho, amor. A Olegário Maciel sempre vai ser o meu lar, independentemente de onde eu esteja.

Ao meu orientador Paulo Vinicius Soares, por tantos anos de história, amizade e confiança em mim. Obrigada por cada oportunidade e cada desafio. Tenho muito orgulho de onde chegamos como grupo e sei que nossa trajetória não acaba aqui. Muito pelo contrário!

A família LNC, em especial a Livia, Alexandre, Rafaella, Igor, Guilherme, Andrea, Amanda, por me darem todo o apoio do mundo, sempre que eu precisei, dentro e fora da faculdade. Tenho orgulho da nossa trajetória como grupo e levarei todos vocês comigo, por onde eu for, dentro e fora da profissão.

A querida Priscilla, que aceitou a missão nos últimos minutos do segundo tempo de me “formar” doutora. O meu carinho por você é enorme e antigo, e se eu pudesse escolher alguém pra estar comigo nesse momento, escolheria exatamente você. Nada é por acaso. Obrigada por tanto.

Aos demais professores, funcionários e colegas da Faculdade de Odontologia da Universidade Federal de Uberlândia, pelos quase 11 anos de história. Me sinto muito grata e orgulhosa de fazer parte dessa instituição. Obrigada por cada um que me fez ser a profissional que sou hoje.

A Universidade de Groningen, pelo fomento e apoio oferecido para que esse trabalho acontecesse, em especial aos queridos professores Marco Gresnigt, Renske Thomas e Dagmar Slot, que me acolheram tanto e tão bem durante a minha estadia na Holanda.

As secretárias do consultório, Lamony e Flávia, que me ajudam tanto e fazem minha vida infinitamente mais fácil. Vocês são muitos especiais e sou muito privilegiada por trabalhar com pessoas como vocês.

Aos amigos Alexia, Tatiana e Ramon pelo suporte emocional imenso que me deram durante esses quatro anos. Vocês sabem o que significam, a importância de vocês na minha vida, e que sem vocês três, eu teria enlouquecido há tempos. Amo muito vocês, little themons.

A Laiz Leão, que foi fundamental nessa reta final. Não existem palavras suficientes pra agradecer tudo que você fez por mim até aqui. Obrigada por tantos momentos maravilhosos, todas as viagens, perrengues, risadas, cervejas, incentivos mil. A sua fé em mim me fez ter fé em mim também, e sem isso eu não estaria aqui hoje.

A Floor Vosmeijer, um presente que o doutorado sanduíche me deu e que vou levar pra vida. Obrigada por todas as conversas, conselhos, beertjes, stroopwafles, hot dogs, aulas de holandês, tudo. Sem você, eu não teria a saudade que tenho da Holanda hoje. Ik hou van je, my flower power.

Aos colegas e professores do Centro Universitário do Triângulo, em especial a coordenadora Renata Georjutti, que depositou tanta confiança em mim e me fez crescer tanto como profissional. Ser professora é uma realização na minha vida e só me fez ter mais certeza do caminho que quero trilhar daqui pra frente.

Aos meus alunos, nem tenho palavras. Se eu ensinei vocês tanto quanto vocês me ensinaram sobre mim, minha missão está cumprida (por ora). Obrigada por acreditarem em mim e me mostrarem o real sentido da minha profissão.

Ao Centro de Pesquisa de Biomecânica, Biomateriais e Biologia Celular – CPBio, da Universidade Federal de Uberlândia, pela disponibilização da estrutura e dos equipamentos para execução de parte deste trabalho.

A CAPES, pelo apoio e incentivo a pesquisa através da bolsa de doutorado.

Por último e não menos importante, a Deus que, sabendo exatamente do que e de quem eu precisava, colocou essa galera toda aí no meu caminho.

We did it!

"Isso de querer ser exatamente aquilo
que a gente é, ainda vai nos levar além."

Paulo Leminski

SUMÁRIO

RESUMO/PALAVRAS-CHAVE

A lesão cervical não cariosa (LCNC) é a perda de estrutura dentária próximo a junção cemento-esmalte (JCE) que não está associada a presença de microorganismos, apresentando uma prevalência conhecida de 5% a 85%. Autores sugerem que sua formação e progressão apresenta etiologia multifatorial, com a combinação dos fatores fricção (atrição e abrasão), biocorrosão e estresse oclusal. O objetivo deste estudo foi reunir toda a literatura disponível para 1) determinar a prevalência mundial estimada das lesões cervicais não cariosas e 2) determinar os fatores de risco associados com as lesões cervicais não cariosas, através de revisões sistemáticas da literatura. O terceiro objetivo foi avaliar a relação entre o padrão de distribuição de tensões, diferentes cargas oclusais e o desenvolvimento das LCNCs, através de análise tridimensional por elementos finitos. Os resultados demonstraram que a prevalência mundial das lesões não cariosas é de aproximadamente 46.7%, aumentando conforme a idade, sendo influenciada por diferentes regiões geográficas, diferentes tipos de população, diferentes termos e definições utilizadas para se referir a doença, entre outros aspectos. Os fatores de risco considerados associados foram idade, frequência de escovação, força colocada na escovação dentária, dureza da escova dental, exposição a ácidos intrínsecos e extrínsecos, hábitos parafuncionais, aspectos oclusais, dentre outros, deixando clara a multifatoriedade de sua etiologia. E, por fim, dentre as limitações impostas por um estudo laboratorial, foi constatado que o padrão de distribuição de tensões no osso alveolar não é influenciado pela presença de lesões cervicais não cariosas, independentemente do tipo de carga oclusal aplicada.

Palavras-chave: lesões cervicais não cariosas, prevalência, fatores de risco.

ABSTRACT/KEYWORDS

Non-carious cervical lesion (NCCL) is the loss of tooth structure close to the cemento-enamel junction (CEJ), which is not associated with the presence of microorganisms, with a known prevalence of 5% to 85%. Authors suggest that its formation and progression have a multifactorial etiology, with the combination of friction (attrition and abrasion), biocorrosion and occlusal stress factors. The aim of this study was to gather all available literature to 1) determine the estimated worldwide prevalence of noncarious cervical lesions and 2) to determine the risk factors associated with noncarious cervical lesions, through systematic reviews of the literature. The third objective was to evaluate the relationship between the stress distribution pattern, different occlusal loads and the development of NCCLs, through three-dimensional finite element analysis. The results showed that the worldwide prevalence of non-carious lesions is approximately 46.7%, increasing according to age, being influenced by different geographical locations, different types of populations, different terms and definitions used to refer to the disease, among other aspects. The risk factors considered associated with NCCL were age, frequency of brushing, vigorousness/power of tooth brushing, toothbrush hardness, exposure to intrinsic and extrinsic acids, parafunctional habits, occlusal aspects, among others, making the multifactorial nature of its etiology clear. Finally, among the limitations imposed by a laboratory study, it was found that the pattern of stress distribution in the alveolar bone is not influenced by the presence of non-carious cervical lesions, regardless of the type of occlusal load applied.

Key-words: noncarious cervical lesion, prevalence, risk factors.

1 INTRODUÇÃO E REFERENCIAL TEÓRICO

As mudanças no cenário político e mundial fizeram com que as políticas públicas de saúde se transformassem nas últimas décadas. O aumento da expectativa de vida concomitante ao aumento do estresse da sociedade devido a maiores jornadas de trabalho, somados à industrialização da sociedade como um todo, com dietas cada vez mais ácidas, fez com que o cenário odontológico também mudasse (Hawkins *et al.*, 2004). As doenças originadas por microorganismos como a cárie e a ~~doença periodontal~~ foram perdendo seu espaço para alterações como a hipersensibilidade dentinária, recessões gengivais, disfunções temporo-mandibulares e como objeto de estudo deste trabalho, as lesões cervicais não cariosas (Orchardson *et al.*, 1994). A etiologia dessas doenças é amplamente discutida na literatura atual, por serem consideradas multifatoriais.

A lesão cervical não cariosa (LCNC) é, por definição, a perda de estrutura dentária próximo a junção cemento-esmalte (JCE) que não está associada a presença de microorganismos (Aw *et al.*, 2002), apresentando uma prevalência de 5% a 85% (Michael *et al.*, 2009). Autores sugerem que sua formação e progressão apresenta etiologia multifatorial, com a combinação dos fatores fricção (atrição e abrasão), biocorrosão e estresse oclusal (Grippo *et al.*, 2012). O termo "erosão" também é comumente utilizado para se referir ao papel dos elementos ácidos sob a estrutura dentária (Barron *et al.*, 2003; Dawes *et al.*, 2003; Bartlett *et al.*, 2009).

Uma variação tão ampla da prevalência pode estar ligada à dificuldade de diagnóstico, falta de padronização nos métodos de avaliação e diferenças básicas entre as sociedades estudadas, como diferenças geográficas, socioeconômicas e culturais existentes. Estudos mostram que a idade está significativamente associada à maior prevalência de lesões (Aw *et al.*, 2002; Teixeira *et al.*, 2018), sugerindo mais um fator responsável pelos diferentes dados de prevalência encontrados na literatura.

O papel exato de cada fator de risco das LCNCs também é amplamente discutido e ainda não há consenso entre os estudos. Acredita-se mais na associação de fatores do que na ocorrência isolada de cada um deles. Associa-se tensão e biocorrosão por exemplo, através da presença de hábitos parafuncionais como o bruxismo, tão presente nos dias atuais, concomitante a uma dieta ácida e/ou doenças gástricas que diminuem o ph do meio bucal (Grippo *et al.*, 2012; Grippo and Oh, 2013); fricção e biocorrosão, através da escovação imediata pós alimentação ácida (Eisenburger *et al.*, 2003); e tensão e fricção, onde um fator potencializa o efeito do outro, acelerando o processo de desgaste cervical (Lintonjua *et al.*, 2004).

As LCNCs são frequentemente associadas com recessões gengivais (RG) e hipersensibilidade dentinária (HD) (Sangnes and Gjermo, 1976; Litonjua *et al*., 2004; Teixeira *et al*., 2018), e isso se deve ao fato de que a exposição radicular facilita o desgaste dentário e a ação dos fatores de risco. Em lesões mais profundas, a proximidade da polpa é uma questão e pode explicar a correlação positiva encontrada entre entre a profundidade das lesões e o nível de sensibilidade dentinária dos pacientes (Pashley, 2013; Teixeira *et al*., 2018).

Além disso, um fator comum importante entre as lesões cervicais não cariosas e a hipersensibilidade dentinária é a presença de carga excessiva associada a forças oclusais (Rees, 2000; Dejak and Młotkowski, 2011), sendo o carregamento oblíquo, que acontece principalmente nos movimentos excursivos, o mais prejudicial para a estrutura dentária e também para o osso alveolar, pois altera o padrão de distribuição das forças (Ichim *et al*., 2007; Soares *et al*., 2014). Vários estudos investigaram as distribuições de tensão em dentes com diferentes quantidades de perda óssea alveolar (Cobo *et al*., 1993; Cobo *et al*., 1996; Geramy, 2000; Wood *et al*., 2008), mas não sabe-se ao certo se existe alguma relação entre a perda óssea e o desenvolvimento das LCNCs.

Considerando todos os aspectos acima expostos, este trabalho tem como objetivos: 1) determinar a prevalência mundial estimada das lesões cervicais não cariosas através de revisão sistemática da literatura; 2) determinar os fatores de risco associados com as lesões cervicais não cariosas através de revisão sistemática da literatura; e por fim, 3) avaliar a relação entre o padrão de distribuição de tensões, diferentes cargas oclusais e o desenvolvimento dessas lesões, por meio de análise tridimensional por elementos finitos.

Capítulo 1

Original research: ***Prevalence of noncarious cervical lesions among adults: A systematic review***

Teixeira DNR, Thomas RZ, Soares PV, Cune MS, Gresnigt MMM, Slot DE. J Dent. 2020 Apr;95:103285. doi: 10.1016/j.jdent.2020.103285. Epub 2020 Jan 30.

Journal of Dentistry 95 (2020) 103285

Contents lists available at ScienceDirect

Journal of Dentistry

journal homepage: www.elsevier.com/locate/jdent

Review article

Prevalence of noncarious cervical lesions among adults: A systematic review

Daniela Navarro Ribeiro Teixeira[a,b], Renske Z. Thomas[a,g], Paulo Vinicius Soares[b], Marco. S. Cune[a,c,d], Marco M.M. Gresnigt[a,e,*], Dagmar Else Slot[f]

[a] University Medical Center Groningen, University of Groningen, Center for Dentistry and Oral Hygiene, Department of Restorative Dentistry and Biomaterials, Groningen, the Netherlands
[b] Federal University of Uberlândia, NCCL Research Group, Department of Restorative Dentistry, School of Dentistry, Uberlândia, Brazil
[c] St. Antonius Hospital, Department of Oral Maxillofacial Surgery, Prosthodontics and Special Dental Care, Nieuwegein, the Netherlands
[d] University of Utrecht, University Medical Center Utrecht, Department of Oral Maxillofacial Surgery, Prosthodontics and Special Dental Care, Utrecht, the Netherlands
[e] Martini Hospital, Department of Special Dental Care, Groningen, the Netherlands
[f] Academic Centre for Dentistry Amsterdam (ACTA), Department of Periodontology and Department of Pediatric Dentistry, University of Amsterdam and VU Universiteit, Amsterdam, the Netherlands
[g] Radboud University Medical Center, Radboud Institute for Health Sciences, Department of Dentistry, Nijmegen, the Netherlands

ARTICLE INFO

Keywords:
Dental
Non-carious cervical lesions
Prevalence
Epidemiology
Cross-sectional studies
Systematic review

ABSTRACT

Objectives: This study aims to systematically review the literature on noncarious cervical lesions (NCCLs) and calculate an overall prevalence estimate.
Methods: The protocol of this systematic review was prepared according to PRISMA and MOOSE guidelines. The MEDLINE-PubMed and Cochrane-CENTRAL databases were searched. Relevant published papers that provided information regarding the prevalence or number of NCCLs among general or specific populations were included.
Results: The initial search identified 569 titles and abstracts, 24 of which met the eligibility criteria involving 14,628 participants. The weighted mean prevalence of NCCLs among the whole studied population was 46.7 % (95 % CI: 38.2; 55.3 %), ranging from 9.1%–93%. Based on sub-analyses, studies with populations older than 30 years revealed higher weighted prevalence (53 %) than those with populations younger than 30 years (43 %). Regarding the diagnostic method, when visual or tactile clinical examination was used, the prevalence was lower than when the Smith and Knight tooth wear index was used. When different definitions were used, the weighted mean prevalence varied from 28 % to 62 %. As to the terms used to address the lesions, the prevalence was higher when "noncarious cervical lesion" was used and lower when "root defects," "abrasion," or "abfraction" were used. When geographical regions were compared, South America had the highest reported prevalence of NCCLs, while the United States had the lowest. Moreover, general populations presented the highest prevalence, slightly higher than dental populations, whose members frequented dental practices.
Conclusion: The overall prevalence of NCCLs was 46.7 % and higher in older populations. Visual and tactile clinical examination underestimate this prevalence compared to the established index. The terms and definitions used also influenced the prevalence data. Distinct geographical differences were observed, and general populations were more inclined to present NCCLs.

1. Introduction

A noncarious cervical lesion (NCCL) is defined as a defect resulting from the loss of tooth structure at the cementoenamel junction (CEJ) that is not related to bacteria [1]. Noncarious cervical lesions are also commonly referred to as "abfraction lesions" [2–7], "cervical wear" [8–11], "cervical abrasions" (or "noncarious cervical tooth surface loss" [12], "abfraction-like cervical lesions" [13] and "vestibular cervical dental abfractions" [14]. The etiology of NCCLs is considered multifactorial, with combinations of friction (attrition and abrasion), biocorrosion, and occlusal stress [7]. The term "erosion" is also used to refer to the role of acids in tooth wear [15–17].

Debate regarding all these etiological factors, including which process is dominant, persists [11,18,19]. Tooth substrate loss due to attrition, abrasion, and erosion is not found only in the cervical region, which complicates the diagnosis of NCCLs. In 1984, Lee and Eakle

* Corresponding author at: University Medical Center Groningen, Department of Restorative Dentistry and Biomaterials, Center for Dentistry and Oral Hygiene, The University of Groningen, Antonius Deusinglaan 1, 9713 AV, Groningen, the Netherlands.
E-mail address: marcogresnigt@yahoo.com (M.M.M. Gresnigt).

https://doi.org/10.1016/j.jdent.2020.103285
Received 17 August 2019; Received in revised form 2 December 2019; Accepted 29 January 2020

[20]—in an attempt to create a clearer definition—thus began to discuss and segregate the different etiological factors of noncarious loss of tooth structure. In 1992 [21], the term "noncarious cervical lesion" was being used, and in 1994, Levitch [18] accurately discussed each etiological factor that was somehow related to the development of NCCLs to clarify their cause, diagnosis, treatment, and prevention.

Despite all past discussion on the subject, different approaches are still being used to classify and diagnose NCCLs. Some studies identify any loss of tissue at the CEJ as an NCCL [22–25]; others consider only wedge-shaped lesions [26–28] or 1-mm-deep lesions [1,9,29] to be NCCLs. A large variation in the reported prevalence rates of NCCLs is present in epidemiological studies, ranging from 5 % to 85 %. This variation might result from using different nomenclature for the same alteration; diversity in the definition, diagnosis, and assessment method used; and variance in the geographical location, time period, and type of population studied [1,11,13,18,27,30–34].

The reported prevalence of NCCLs in different geographical locations seems to vary considerably, yet no previous studies have estimated the worldwide prevalence. This study therefore aims to systematically review the literature to estimate the worldwide prevalence of NCCLs in the adult population, while a sub-analysis intends to clarify the large variation in rates.

2. Methods

More details of this systematic review as included and excluded studies, sub-analysis, quality assessment and guidelines can be seen in the Online Appendix Supplement (Tables S1–S7). The protocol of this systematic review was prepared according to PRISMA and MOOSE guidelines (see Online Appendix S6 and S7). The focused research question was also prepared as follows: What is the worldwide prevalence of noncarious cervical lesions (NCCLs) among adults? For details regarding the search terms used, see Table 1.

2.1. Search strategy

Two online sources were used to find research papers that satisfied the purpose of this study: the National Library of Medicine, Washington, DC (MEDLINE-PubMed), and the Cochrane Central Register of Controlled Trials (CENTRAL). Databases were searched for eligible studies conducted in or earlier than November 2018 according to the following criteria: studies in the English language; human subjects ≥16 years old; diagnosed with NCCLs as assessed by dental care professionals; and cross-sectional study design reporting the prevalence of NCCLs in an adult population.

2.2. Screening and selection

Two independent reviewers (DNRT and RZT) screened the titles and abstracts to find eligible papers. If eligible aspects were present in the title, the paper was selected for further reading; if not, the abstract and key words were screened for suitability. The two reviewers then read all selected full-text papers in detail. Any disagreement between the two was resolved with additional discussion, and if disagreement persisted, the judgment of a third reviewer (DES) was decisive. The papers that fulfilled all the selection criteria were processed for data extraction. For those papers that provided insufficient data to be included in the analysis, the first or corresponding author was contacted in an attempt to obtain additional data.

Table 1
Search strategy and terms.

Search terms used for PubMed-MEDLINE and Cochrane Library. The search strategy was customized appropriately according to the database being searched considering differences in controlled vocabulary and syntax rules. The following strategy was used: ((Non caries cervical lesions) OR (Non caries cervical lesion*) OR (Non caries cervical lesion) OR (Non carious cervical lesions) OR (Non carious cervical lesion*) OR (Non carious cervical lesion) OR (Abfraction AND dental))

The asterisk (*) was used as a truncation symbol.

2.3. Data extraction and methodological quality assessment

The same two independent reviewers processed data from the papers that met the selection criteria for further analysis. The focus was the prevalence of NCCLs among adult populations. Percentages concerning the prevalence of NCCLs were thus extracted. However, if the selected paper did not provide the prevalence of NCCLs but did report on the number of subjects with the alteration, the prevalence was calculated by dividing the number of patients who presented NCCLs during the time period specified by the size of the population under investigation. The heterogeneity across studies was detailed according to the following factors: subjects' characteristics, the geographical region of the investigated population; NCCL definition; diagnostic criteria for NCCLs; and the prevalence of NCCLs (see online appendix S1).

2.4. Risk of bias

The methodological qualities of the included studies were subsequently assessed according to the quality criteria on the Joanna Briggs Institute's "Checklist for Analytical Cross Sectional Studies" [35]. When the sources of data and details on the methods of assessment, description or consideration of potential sources of bias, calibration or training of examiners, definition of noncarious cervical lesions, and whether the investigated group was a representative population were provided, the study was considered to have a low risk of bias.

2.5. Data analysis

The overall weighted mean prevalence percentage was calculated using SPSS Statistics 21.0. To assign more weight to the studies that carry more information for this analysis, each included study was assigned a weight according to its sample size. Due to the heterogeneity of the data, it was determined a priori to perform a quantitative sub-analysis for age group, type of population, geographical location per continent where the study was conducted, the definition of "NCCL" used, the diagnosis of NCCLs, and the terms used to address NCCLs. For a detailed overview of which studies were used per analysis, see Online Appendix S4.

2.6. Grading

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group's GRADE method was used to appraise the evidence that emerged from this review. The three aforementioned reviewers rated the body of evidence, and any disagreement was resolved with additional discussion.

3. Results

3.1. Search results

The comprehensive search identified 569 unique papers. The screening of titles and abstracts resulted in 69 full-text papers, of which 36 were excluded for not meeting the eligibility criteria (see Fig. 1, online appendix S2), resulting in 11 included studies. All reference lists of the selected studies were then hand-searched for additional publications that could possibly meet the eligibility criteria of the study. Thirteen additional studies were thus included (see online appendix S3), totalizing 24 articles to be analyzed (see Table 2).

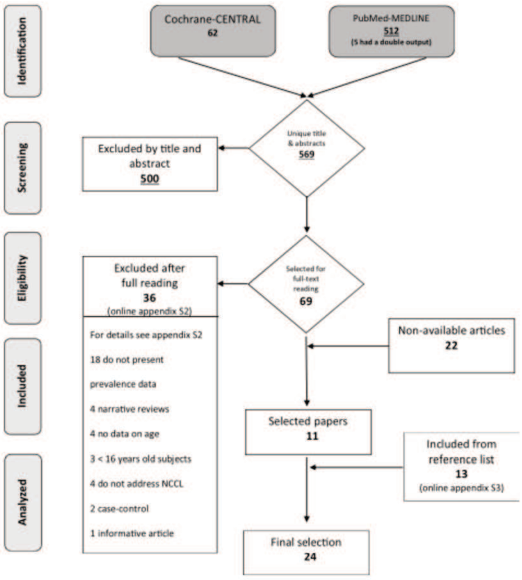


Fig. 1. Search and selection results.

3.2. Characteristics of selected studies

The extracted data regarding study design, the characteristics of the studied population, the definition of "noncarious cervical lesion" (NCCL), criteria and diagnostic methods for NCCLs, and the geographical location of the studies are presented in the online appendix.

An evaluation of the selected papers revealed considerable heterogeneity. The range of the included number of participants within studies was 40–2,707, with a mean of 609.5. Gender was equally distributed in Studies II, VI, and XIX. Conversely, in Studies I, IV, VIII, IX, X, XI, XX, and XXIV, subject groups consisted of more females than males, while Studies III, V, VII, XII, XIII, XIV, XV, XVIII, and XXI consisted of more males than females. Furthermore, the population of Study XXIII was 100 % male. Gender distribution was not stated in Studies XVI, XVII, and XXII.

As to the age range of the studied population, subjects were aged between 16 and 75 years old. Studies IV, VI, VII, X, XII, XVI, and XXIV included only those older than 30. Similarly, Studies X, XV, XVIII, XIX, XX, and XXIV used restricted age groups, which can represent inclusion criteria bias.

Subjects who frequented dental practices were included in Studies I, VII, VIII, IX, XI, XIII, XVIII, and XIX. While general representative populations were assessed in Studies II, IV, V, VI, X, XIV, XV, XVI, XVII, XXI, XXII, XXIII, and XXIV, specific populations were assessed in Studies III (Worker's Health Center Reference population), XII (population with increased risk of oral disease), and XX (military personnel population). Moreover, Europe, Asia, and South America were the most assessed regions, discussed in 37.5 %, 25 %, and 21 % of the studies, respectively.

Regarding diagnostic methods, most of the studies used visual or tactile clinical examination to detect NCCLs. The Smith and Knight tooth wear index was used for assessment in Studies II, IV, and XXIII, while Study VI favored a modified index based on Smith and Knight's. Only Study VII assessed clinical signs on accurate diagnostic casts and was thus excluded from the sub-analysis.

Finally, "noncarious cervical lesions" was the term used to refer to the lesions in Studies I, II, III, IV, V, VI, VIII, IX, XIV, XV, XVI, XVIII,

Table 2
Overall characteristics of the included studies, for further details see Table S1 (online supplement).

Author/year Study location Study design Risk of bias	Participants' age	Method of NCCL assessment	Cases of NCCL Total sample	Prevalence
(I) Yoshizaki, 2017 [1] Brazil Cross-sectional Low	Older than 18 years old	Visual and tactile analysis	80 cases out of 118 subjects	67.8 %
(II) Yang, 2016 [2] China Cross-sectional Moderate	20–69 years old	Smith and Knight tooth wear index (3)	831 cases out of 1320 subjects	63 %
(III) Bomfim, 2015 [4] Brazil Cross-sectional Moderate	20–68 years old	Visual analysis	78 cases out of 100 subjects	76.8 %
(IV) Lai, 2015 [5] China Cross-sectional Moderate	35–44 and 65–74 years old	Smith and Knight tooth wear index (3)	1394 cases out of 1759 subjects	79 %◊
(V) Que, 2013 [6] China Cross-sectional Low	20–69 years old	Visual and tactile analysis	633 cases out of 1023 subjects	61.7 %
(VI) Jiang, 2011 [7] China Cross-sectional Moderate	35–44 and 65–74 years old	Smith and Knight tooth wear index (3)	1029 cases out of 2160 subjects	47.6 %◊
(VII) Tsiggos, 2008 [8] Greece Cross-sectional Moderate	30–55 years old	Clinical signs assessed on accurate diagnostic casts	25 cases out of 102 subjects	24.5 %
(VIII) Smith, 2008 [9] Trinidad and Tobago Cross-sectional High	16–3 years old	Visual examination	97 cases out of 156 subjects	62.2 %
(IX) Kolak, 2018 [10] Servia Cross-sectional Substantial	19–55 + years old	Visual examination	270 cases out of 394 subjects	68.5 %
(X) Hahn, 1999 [11] Germany Cross-sectional Moderate	50–60 years old	Visual and tactile examination	277 cases out of 298 subjects	93 %◊
(XI) Reyes, 2009 [12] USA Cross-sectional Low	23–82 years old	Visual and tactile examination	23 cases out of 46 subjects	50 %◊
(XII) Ringelberg et al., 1996 [13] USA Cross-sectional Substantial	45–75 + years old	Visual and tactile examination	87 cases out of 873 subjects	10 %
(XIII) Akgul et al., 2003 [14] Turkey Cross-sectional High	Older than 20 years old	Visual examination	39 cases out of 428 subjects	9.1 %
(XIV) Bernardt et al., 2006 [15]	20–59 years old	Visual and tactile examination	855 cases out of	31.6 %◊

(continued on next page)

Table 2 (*continued*)

Author/year Study location Study design Risk of bias	Participants' age	Method of NCCL assessment	Cases of NCCL Total sample	Prevalence
Germany Cross-sectional Low			2707 subjects	
(XV) Brandini et al., 2011 [16] Brazil Cross-sectional High	19–31 years old	Visual and tactile examination	31 cases out of 58 subjects	53.5 %
(XVI) Estafan et al., 2005 [17] USA Cross-sectional High	Mean of 28.9 years old	Visual examination of casts	99 cases out of 299 subjects	33.1 %
(XVII) Lussi et al., 1991 [18] Switzerland Cross-sectional Substantial	26–30 and 46–50 years old	Visual and tactile examination	84 cases out of 391 subjects	21.5 %◊
(XVIII) Ommerborn et al., 2007 [19] Germany Cross-sectional Substantial	20–39 years old	Visual examination	27 cases out of 91 subjects	30 %◊
(XIX) Pegoraro et al., 2005 [20] Brazil Cross-sectional Substantial	25–45 years old	Visual and tactile examination	62 cases out of 70 subjects	88 %◊
(XX) Radentz et al., 1976 [21] USA Cross-sectional High	17–45 years old	Visual and tactile examination	40 cases out of 80 subjects	50 %◊
(XXI) Bergstrom & Lavstedt., 1979 [22] Sweden Cross-sectional Moderate	18–65 years old	Visual examination	441 cases out of 1423 subjects	31 %
(XXII) Sangnes & Gjermo, 1976 [23] Norway Cross-sectional High	18–50+ years old	Visual and tactile examination	240 cases out of 533 subjects	45 %
(XXIII) Takehara et al., 2008 [24] Japan Cross-sectional Moderate	20–50+ years old	Smith and Knight tooth wear index (3)	78 cases out of 159 subjects	49.1 %
(XXIV) Telles et al., 2006 [25] Brazil Cross-sectional High	16–22 years old	Visual and tactile examination	29 cases out of 40 subjects	72.5 %◊

◊ - calculated by the authors of this review based on the presented data in the selected paper.

XIX, XXIII, and XXIV. "Root defects" was used in Studies X and XII; "abfractions" in Studies VII and XI; "abrasion" in Studies XII, XX, XXI, and XXII; and "erosion" in Study XVII. Additionally, Studies II, III, V, IX, XVIII, and XXIII referred to the definition Aw et al. established in 2002, while Studies VIII, XIII, XV, and XVI referred to the definition Levitch et al. established in 1994.

3.3. *Risk of bias assessment*

The quality assessment values, including methodology and statistical validity, are presented in the online appendix S5. Based on a summary of these criteria, the estimated potential risk of bias was low for four studies, moderate for eight, substantial for five, and high for seven.

3.4. *Data analysis*

The meta-analysis could not be conducted due to the heterogeneity of the data; the weighted mean prevalence of NCCLs among the whole studied population was therefore 46.7 % (see Table 2). Data concerning the presence of NCCLs in the population were extracted or calculated from 24 papers that involved 6,844 NCCL cases altogether. The prevalence ranged from 9.1%–93% (see Table 1). A weighted mean prevalence was calculated including four (I, V, XI, and XIV) that had a low estimated risk of bias, which resulted in an overall weighted mean prevalence of NCCLs among subjects of 40.7 %.

The sub-analysis is presented in Table 3. Concerning age, studies with older populations indicated a higher weighted prevalence (54 %), while studies whose populations also included younger subjects indicated a lower weighted prevalence (43 %). Regarding diagnostic methods, when visual or tactile clinical examination was used, the prevalence was 38 % (n = 9,128); when the Smith and Knight tooth wear index was used, the prevalence was about 62 % (n = 5,398. Furthermore, when different definitions were used, the weighted mean prevalence varied from 28 % [18] to 62 % [1]. As to the terms used to address lesions, the prevalence was higher when "noncarious cervical lesion" was used (53 %) and lower when "root defects," "abrasion," or "abfraction" were used (30 %). The prevalence in South America was the highest of all geographical regions (69 %, n = 542), and North America (i.e., the United States) had the lowest prevalence (19 %, n = 1,298. Both regions used visual and tactile clinical examination as diagnostic methods, which prevents bias in the comparison. In between, Europe had a prevalence of 35 % (n = 6,367, while Asia had a prevalence of 62 % (n = 6,421). General populations presented the highest prevalence 54 %, n = 9,463. Moreover, when the population frequented dental practices, the prevalence was about 44 % (n = 1,405).

3.5. *Grading*

Table 4 reviews the factors used to establish the body of evidence according to GRADE [36] and the risk of magnitude. Considering that a high heterogeneity was found between the included studies, as well as on the basis of sub-analysis, the magnitude of this observation depends on the method of assessment used to diagnose NCCLs, the age range of the studied subjects, the type of population, the geographical location studied, and the definition and terms used to address NCCLs. This paper thus proposes that the groups of subjects, diagnostic criteria, definitions, and terms used for NCCLs should be standardized in future studies.

4. Discussion

This systematic review addresses the available body of dental literature concerning an important issue that is prevalent among diverse populations: noncarious cervical lesions (NCCLs). The weighted mean prevalence of NCCLs was 47 % among the studied populations—confirming its importance and clinical relevance—varying from 9 % in a Turkish study [37] to 93 % in a German one [32] (see Table 2). This range is slightly higher than the findings of current literature, which report a prevalence of 5 %–85 % [18]. This variation may be due to inclusion bias in Hahn et al.'s study [32], which included only subjects of a restricted age group (50–60 years old). As demonstrated in past studies [1,31,38,39] and this review, age can be a determining factor

Table 3
Overall analysis and sub analysis on the weighted mean prevalence of included studies. (See online appendix S4 showing which studies were used per analyses).

	N. of Studies	N. of lesions – N. of participants	WM (SD)	95 %CI*
(A) Overall analysis				
Total	**24**	**6844–14628**	**46.75 (21.44)**	**[38.18;55.32]**
(B)Sub analysis on age				
Only 30+ subjects	5	2765–5192	54.06 (25.66)	[53.36;54.76]
16-30+	19	4037–9436	42.76 (17.40)	[42.41;43.11]
(C)sub analysis on population				
General population	13	6016–12170	49.39 (18.29)	[44.2;64.88]
Dental population	8	623–1405	44.32 (27.6)	[25.20;63.44]
Specific population	3	205–1053	19.39 (12.53)	[15.75;40.30]
(D)Sub analysis on geographical location				
South America	6	377–542	69.27 (09.90)	[61.36;77.19]
North America	4	249–1298	19.20 (16.10)	[3.42;34.97]
Europe	9	2253–6367	35.39 (17.39)	[24.03;46.75]
Asia	5	3965–6421	61.68 (12.37)	[50.84;72.52]
(E)Sub analysis on diagnosis				
Visual and/or tactile examination	19	3487–9128	38.19 (20.41)	[29.01;47.36]
Smith and Knight index	4	3332–5398	61.64 (13.49)	[48.43;74.85]
(F)Sub analysis on definition				
Aw (2002)	6	1917–3087	62.09 (7.18)	[59.52;64.66]
Levitch (1994)	4	266–941	28.26 (20.12)	[8.55;47.97]
(G)Sub analysis on terms				
NCCL	15	5588–10454	53.39 (17.46)	[44.56;62.22]
Root defect	2	364–1171	31.12 (36.16)	[29.05;33.19]
Abrasion	4	760–2464	30.84 (11.72)	[19.36;42.32]
Abfraction	2	48–148	32.42 (11.84)	[16.02;48.82]

*As a measure of precision, the standard error of the weighted mean (which reflects the variation among studies) was used relative to the number of experiments available to calculate the lower and upper limits of the 95 % confidence interval of the weighted mean difference.
WM = weighted mean.
SD = standard deviation.
95 %CI = 95 %confidence interval.

Table 4
GRADE evidence profile.

Study design	Cross-sectional
Risk of bias	Low to high
Consistency	Rather inconsistent
Precision	Rather precise
Directness	Rather generalizable
Publication bias	Possible
Body of evidence	Low to moderate
Magnitude of the finding	Moderate

for the prevalence of NCCLs, since older populations have probably been exposed to the etiological factors longer than younger ones. Hahn et al. [32] also used the term "root defect" to refer to NCCLs, whether from erosive, abrasive, or even abfraction processes, which may have led them to include more lesions per patient. These considerations, among others, demonstrate potential bias in the estimation of NCCL prevalence for the whole studied population from 24 papers.

The definition and diagnosis of NCCLs have long been discussed. As NCCLs come in a large variety of forms, some studies have demonstrated that different lesion shapes are often related to the prevalence of specific etiological factors [40,41], and different terms have been used to define these lesions, including "root defects" [32,42], "abrasion" [37,43–45], "abfraction" [26,27], and "erosion" [46]. As per a recent morphological classification [47], proposed in an attempt to reduce the confusion and misunderstanding regarding the appearance of these lesions, NCCLs can be classified according to their appearance as shallow, concave, wedge-shaped, notched, and irregular. In the past, terms such as "dished-out," "saucer-shaped," "cupped," "c-shaped," "v-shaped," "shallow grooves," "grooved," "gingival notching," and "deep notches" [1,48–52] were used. Additionally, the most commonly used method of NCCL diagnostic assessment found in the included studies was visual or tactile clinical examination [22,26,28,32,33,37,38,42–46,53–59], followed by the Smith and Knight tooth wear index [24,29,60–62]. As clinical examination does not present specific grading, the lower weighted prevalence found when comparing the use of this method to that of Smith and Knight's tooth wear index may result from the difficulty of establishing a given pattern. Moreover, the studies that used Smith and Knight's index were conducted in Asia, a populous region, which supports the higher prevalence. The recognition and knowledge of the appearance of NCCLs remains unclear, as the studies included in this review reveal a high heterogeneity.

The different definitions used to describe NCCLs may also contribute to the high variance of reported prevalence rates [1,11,18,43,45,63,64]. Aw et al.'s is used most often and states that an NCCL is "a loss of tooth structure at the cementoenamel junctional level unrelated to dental caries" [1]. However, CEJ location can be confused with the coronal border of the cervical lesion, which means that the recognition and definitive diagnosis of NCCLs remains difficult from a clinical perspective [65]. In turn, the difficulty of differentiating early shallow NCCLs and gingival recession persists, compromising the diagnosis and resulting in a higher or lower prevalence. This lack of standardized definitions therefore strengthens the bias across studies.

The large number of included studies allowed for sub-analysis by geographical region as summarized in Table 2, with the corresponding weighted mean values. The highest prevalence of NCCLs among adults was observed in studies conducted in South America (69 %, $n = 542$), especially in Brazil. All the studies used visual or tactile clinical examination to assess the NCCLs; however, only two included subjects from the general population [22,56], which may have raised the estimated prevalence. The prevalence in Asia was estimated to be 61 % (n = 6,421), and four of the five studies conducted in this location used the Smith and Knight tooth wear index to assess the NCCLs, which, according to the data, also had a prevalence of 61 % (n = 5,398. Conversely, four American studies reported a prevalence of only 19 % (n = 1,053, possibly since one study [26] included only abfraction NCCLs, which are sharp and wedge-shaped. The second study [42] considered only defects with more than 2 mm of axial depth, disregarding the other types of lesions; the third was assessed through cast evaluation [57]; and the fourth presented a specific population, not being representative enough [43]. All these aspects together tended to lower the prevalence.

Table 2 also indicates that the type of population influences the prevalence data, as this aspect varied from 19 % for specific populations (n = 1,053) to 49 % for general populations (n = 12,170). In fact, general populations are more heterogeneous and thus present wider variation and different etiological factors, which raises the prevalence of the variance in question, precisely because it is considered multifactorial [7,11,18,19]. It is therefore evident that the studied subjects' characteristics are indeed relevant to the estimation of the prevalence of NCCLs, since they concern the risk factors of NCCLs.

5. Limitations and future recommendation

As the data presented in this systematic review are heterogenous due to a lack of standardization, a meta-analysis could not be conducted. Nevertheless, the guidelines for future studies should consider creating or standardizing an index that could be used to diagnose early and advanced NCCLs, thus allowing researchers to compare results from different studies or even conduct multivariate analyses in large-scale studies. Future generations must be alerted to the early diagnosis and treatment of NCCLs, which are increasingly common in dental care practice. These clinical manifestations can affect a patient's quality of life and understanding them can help to prevent potential future problems, such as dentin hypersensitivity and gingival recession, among others. Ethics approval: Not applicable/not required.

6. Conclusion

The worldwide prevalence of NCCLs among adults is 46.7 % and higher in older populations than younger ones. The established index also supports the rise in prevalence when compared to visual and tactile clinical examination. South America has the highest prevalence of NCCLs among different geographical regions, and general populations are more inclined to present these lesions than specific ones.

Author contributions

Daniela Navarro Ribeiro Teixeira: contributed to conception, design, acquisition, analysis, interpretation of data and drafted the manuscript.

Renske Z. Thomas: contributed to conception, design, acquisition, analysis, interpretation of data and critically revised the manuscript for important intellectual content.

Paulo Vinicius Soares:contributed to interpretation of data and critically revised the manuscript for important intellectual content.

Marco. S. Cune: contributed to interpretation of data and critically revised the manuscript for important intellectual content.

Marco M. M. Gresnigt:contributed to conception, interpretation of data and critically revised the manuscript for important intellectual content.

Dagmar Else Slot: contributed to conception, design, analysis, interpretation of data and critically revised the manuscript for important intellectual content. All authors gave final approval and agree to be accountable for all aspects of the work in ensuring that questions relating to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Funding

No commercial funding was received for this review. Navarro Ribeiro Teixeira received a personal grant by the University Medical Center Groningen. This research received no specific other grants from any funding agency in the public, commercial, or non-profit sector. The work for this paper was also funded by the regular appointments of Thomas, Cune & Gresnigt at the University of Groningens, Slot at the Academic Centre for Dentistry Amsterdam (ACTA) and Soares at Federal University of Uberlandia.

Declaration of Competing Interest

The authors did not have any commercial interest in any of the materials used in this study and each of the authors listed below declare no conflict of interest.

Acknowledgements

The authors thank Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Brasil (CAPES) for one year of Phd scholarship, and the University of Groningen, which financed the first author for an internship conducting this systematic review. We also thank UoG Library, which provided the papers used in this review.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jdent.2020.103285.

References

[1] T.C. Aw, X. Lepe, G.H. Johnson, L. Mancl, Characteristics of noncarious cervical lesions: a clinical investigation, J. Am. Dent. Assoc. 133 (2002) 725–733 http://www.ncbi.nlm.nih.gov/pubmed/12083648.

[2] A.M.B.R. da Silva, L. Valencise Magri, M.A.M.R. da Silva, M.D. de Sousa Neto, Are the bite force and electromyographic activity altered in muscle TMD patients with abfraction lesions? Cranio - J. Craniomandib. Pract. 9634 (2017) 1–7, https://doi.org/10.1080/08869634.2017.1407116.

[3] N. Miller, J. Penaud, P. Ambrosini, C. Bisson-Boutelliez, S. Briançon, Analysis of etiologic factors and periodontal conditions involved with 309 abfractions, J. Clin. Periodontol. 30 (2003) 828–832, https://doi.org/10.1034/j.1600-051X.2003.00378.x.

[4] J.S. Rees, M. Hammadeh, Undermining of enamel as a mechanism of abfraction lesion formation: a finite element study, Eur. J. Oral Sci. 112 (2004) 347–352, https://doi.org/10.1111/j.1600-0722.2004.00143.x.

[5] L. a Litonjua, S. Andreana, A.K. Patra, R.E. Cohen, An assessment of stress analyses in the theory of abfraction, Biomed. Mater. Eng. 14 (2004) 311–321 http://www.ncbi.nlm.nih.gov/pubmed/15299243.

[6] I.D. Wood, A.S.A. Kassir, P.A. Brunton, Effect of lateral excursive movements on the progression of abfraction lesions, Oper. Dent. 34 (2009) 273–279, https://doi.org/10.2341/08-100.

[7] J.O. Grippo, M. Simring, T.A. Coleman, Abfraction, abrasion, biocorrosion, and the enigma of noncarious cervical lesions: a 20-year perspective, J. Esthet. Restor. Dent. 24 (2012) 10–23, https://doi.org/10.1111/j.1708-8240.2011.00487.x.

[8] A.W.G. Walls, P.T. Silver, J.G. Steele, Impact of treatment provision on the epidemiological recording of root caries, Eur. J. Oral Sci. 108 (2000) 3–8, https://doi.org/10.1034/j.1600-0722.2000.00767.x.

[9] L. Pikdöken, E. Akca, B. Gürbüzer, B. Aydil, B. Taşdelen, Cervical wear and occlusal wear from a periodontal perspective, J. Oral Rehabil. 38 (2011) 95–100, https://doi.org/10.1111/j.1365-2842.2010.02137.x.

[10] M. Addy, R.P. Shellis, Interaction between attrition, abrasion and Erosion in tooth wear, Dent. Eros. 20 (2006) 17–31, https://doi.org/10.1159/000093348.

[11] D.W. Bartlett, P. Shah, A critical review of non-carious cervical (Wear) lesions and the role of abfraction, erosion, and abrasion, J. Dent. Res. 85 (2006) 306–312, https://doi.org/10.1177/154405910608500405.

[12] I. Wood, Z. Jawad, C. Paisley, P. Brunton, Non-carious cervical tooth surface loss: a literature review, J. Dent. 36 (2008) 759–766, https://doi.org/10.1016/j.jdent.2008.06.004.

[13] B.T. Piotrowski, W.B. Gillette, E.B. Hancock, Examining the prevalence and characteristics of abfractionlike cervical lesions in a population of U.S. veterans, J. Am. Dent. Assoc. 132 (2001) 1694–1701, https://doi.org/10.14219/jada.archive.2001.0122.

[14] S.P. Palomino-Gómez, F. Jeremias, L.S. Finoti, G. Paredes-Coz, D.B. Raveli, Influence of lateral excursion on vestibular cervical dental abfraction, Acta Odontol. Latinoam. 24 (2011) 283–288 http://www.ncbi.nlm.nih.gov/pubmed/22550823.
[15] D. Bartlett, Etiology and prevention of acid erosion, Compend. Contin. Educ. Dent. 30 (2009) 616–620 http://www.ncbi.nlm.nih.gov/pubmed/19998728.
[16] R.P. Barron, R.P. Carmichael, M.A. Marcon, G.K.B. Sàndor, Dental erosion in gastroesophageal reflux disease, J. Can. Dent. Assoc. 69 (2003) 84–89 http://www.ncbi.nlm.nih.gov/pubmed/12559056.
[17] C. Dawes, What is the critical pH and why does a tooth dissolve in acid? J. Can. Dent. Assoc. 69 (2003) 722–724 http://www.ncbi.nlm.nih.gov/pubmed/14653937.
[18] L.C. Levitch, J.D. Bader, D.A. Shugars, H.O. Heymann, Non-carious cervical lesions, J. Dent. 22 (1994) 195–207 http://www.ncbi.nlm.nih.gov/pubmed/7962894.
[19] J.O. Grippo, M. Simring, S. Schreiner, Attrition, abrasion, corrosion and abfraction revisited: a new perspective on tooth surface lesions, J. Am. Dent. Assoc. 135 (2004) 1109–1118, https://doi.org/10.14219/jada.archive.2004.0369.
[20] W.C. Lee, W.S. Eakle, Possible role of tensile stress in the etiology of cervical erosive lesions of teeth, J. Prosthet. Dent. 52 (1984) 374–380 http://www.ncbi.nlm.nih.gov/pubmed/6592336.
[21] J.O. Grippo, Noncarious cervical lesions: the decision to ignore or restore, J. Esthet. Dent. (4 Suppl) (1992) 55–64 http://www.ncbi.nlm.nih.gov/pubmed/1298328.
[22] D. Telles, L.F. Pegoraro, J.C. Pereira, Incidence of noncarious cervical lesions and their relation to the presence of wear facets, J. Esthet. Restor. Dent. 18 (2006) 178–183, https://doi.org/10.1111/j.1708-8240.2006.00015.x discussion 184.
[23] J.D. Bader, F. McClure, M.S. Scurria, D.A. Shugars, H.O. Heymann, Case-control study of non-carious cervical lesions, Commun. Dent. Oral Epidemiol. 24 (1996) 286–291 http://www.ncbi.nlm.nih.gov/pubmed/8871039.
[24] H. Jiang, M.Q. Du, W. Huang, B. Peng, Z. Bian, B.J. Tai, The prevalence of and risk factors for non-carious cervical lesions in adults in Hubei Province, China, Commun. Dent. Health 28 (2011) 22–28 http://www.ncbi.nlm.nih.gov/pubmed/21485230.
[25] D.A. Brandini, A.L.B. de Sousa, C.I. Trevisan, L.A.P. Pinelli, S.C. do Couto Santos, D. Pedrini, S.R. Panzarini, Noncarious cervical lesions and their association with toothbrushing practices: in vivo evaluation, Oper. Dent. 36 (2020) 581–589, https://doi.org/10.2341/10-152-S n.d..
[26] E. Reyes, C. Hildebolt, E. Langenwalter, D. Miley, Abfractions and attachment loss in teeth with premature contacts in centric relation: clinical observations, J. Periodontol. 80 (2009) 1955–1962, https://doi.org/10.1902/jop.2009.090149.
[27] N. Tsiggos, D. Tortopidis, A. Hatzikyriakos, G. Menexes, Association between self-reported bruxism activity and occurrence of dental attrition, abfraction, and occlusal pits on natural teeth, J. Prosthet. Dent. 100 (2008) 41–46, https://doi.org/10.1016/S0022-3913(08)60135-3.
[28] O. Bernhardt, D. Gesch, C. Schwahn, F. Mack, G. Meyer, U. John, T. Kocher, Epidemiological evaluation of the multifactorial aetiology of abfractions, J. Oral Rehabil. 33 (2006) 17–25, https://doi.org/10.1111/j.1365-2842.2006.01532.x.
[29] J. Takehara, T. Takano, R. Akhter, M. Morita, Correlations of noncarious cervical lesions and occlusal factors determined by using pressure-detecting sheet, J. Dent. 36 (2008) 774–779, https://doi.org/10.1016/j.jdent.2008.05.009.
[30] A.O. Oginni, A.O. Olusile, C.I. Udoye, Non-carious cervical lesions in a Nigerian population: abrasion or abfraction? Int. Dent. J. 53 (2003) 275–279, https://doi.org/10.1111/j.1875-595X.2003.tb00759.x.
[31] J. Borcic, I. Anic, M.M. Urek, S. Ferreri, The prevalence of non-carious cervical lesions in permanent dentition, J. Oral Rehabil. 31 (2004) 117–123 doi:1223 [pii].
[32] P. Hahn, D. Reinhardt, H.G. Schaller, E. Hellwig, Root lesions in a group of 50-60 year-old Germans related to clinical and social factors, Clin. Oral Invest. 3 (1999) 168–174, https://doi.org/10.1007/s007840050097.
[33] K.T. Yoshizaki, L.F. Francisconi-dos-Rios, M.A.P. Sobral, A.C.C. Aranha, F.M. Mendes, T. Scaramucci, Clinical features and factors associated with non-carious cervical lesions and dentin hypersensitivity, J. Oral Rehabil. 44 (2017) 112–118, https://doi.org/10.1111/joor.12469.
[34] D.N.R. Teixeira, L.F. Zeola, A.C. Machado, R.R. Gomes, P.G. Souza, D.C. Mendes, P.V. Soares, Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: a cross-sectional study, J. Dent. 76 (2018) 93–97, https://doi.org/10.1016/j.jdent.2018.06.017.
[35] T. Briggs Institute Joanna, Joanna Briggs Institute Reviewer's Manual, The Joanna Briggs Institute, Adelaide, 2014.
[36] G.H. Guyatt, A.D. Oxman, V. Montori, G. Vist, R. Kunz, J. Brozek, P. Alonso-Coello, B. Djulbegovic, D. Atkins, Y. Falck-Ytter, J.W. Williams, J. Meerpohl, S.L. Norris, E.A. Akl, H.J. Schünemann, GRADE guidelines: 5. Rating the quality of evidence—publication bias, J. Clin. Epidemiol. 64 (2011) 1277–1282, https://doi.org/10.1016/j.jclinepi.2011.01.011.
[37] H.M. Akgül, N. Akgül, S. Karaoglanoglu, N. Ozdabak, A survey of the correspondence between abrasions and tooth brushing habits in Erzurum, Turkey, Int. Dent. J. 53 (2003) 491–495 http://www.ncbi.nlm.nih.gov/pubmed/14725378.
[38] K. Que, B. Guo, Z. Jia, Z. Chen, J. Yang, P. Gao, A cross-sectional study: non-carious cervical lesions, cervical dentine hypersensitivity and related risk factors, J. Oral Rehabil. 40 (2013) 24–32, https://doi.org/10.1111/j.1365-2842.2012.02342.x.
[39] B.G. Smith, N.D. Robb, The prevalence of toothwear in 1007 dental patients, J. Oral Rehabil. 23 (1996) 232–239 http://www.ncbi.nlm.nih.gov/pubmed/8730269.
[40] J.A. Michael, G.C. Townsend, L.F. Greenwood, J.A. Kaidonis, Abfraction: separating fact from fiction, Aust. Dent. J. 54 (2009) 2–8, https://doi.org/10.1111/j.1834-7819.2008.01080.x.
[41] B. Hur, H.C. Kim, J.K. Park, A. Versluis, Characteristics of non-carious cervical lesions - an ex vivo study using micro computed tomography, J. Oral Rehabil. 38 (2011) 469–474, https://doi.org/10.1111/j.1365-2842.2010.02172.x.
[42] M.L. Ringelberg, G.H. Gilbert, D.E. Antonson, T.A. Dolan, D.W. Legler, U. Foerster, M.W. Heft, Root caries and root defects in urban and rural adults: the Florida dental care study, J. Am. Dent. Assoc. 127 (1996) 885–891 http://www.ncbi.nlm.nih.gov/pubmed/8754463.
[43] W.H. Radentz, G.P. Barnes, D.E. Cutright, A survey of factors possibly associated with cervical abrasion of tooth surfaces, J. Periodontol. 47 (1976) 148–154, https://doi.org/10.1902/jop.1976.47.3.148.
[44] G. Sangnes, P. Gjermo, Prevalence of oral soft and hard tissue lesions related to mechanical toothcleansing procedures, Commun. Dent. Oral Epidemiol. 4 (1976) 77–83 http://www.ncbi.nlm.nih.gov/pubmed/1062255.
[45] J. Bergström, S. Lavstedt, An epidemiologic approach to toothbrushing and dental abrasion, Commun. Dent. Oral Epidemiol. 7 (1979) 57–64 http://www.ncbi.nlm.nih.gov/pubmed/282958.
[46] A. Lussi, M. Schaffner, P. Hotz, P. Suter, Dental erosion in a population of Swiss adults, Commun. Dent. Oral Epidemiol. 19 (1991) 286–290 http://www.ncbi.nlm.nih.gov/pubmed/1742995.
[47] J.A. Michael, J.A. Kaidonis, G.C. Townsend, Non-carious cervical lesions on permanent anterior teeth: a new morphological classification, Aust. Dent. J. 55 (2010) 134–137, https://doi.org/10.1111/j.1834-7819.2010.01228.x.
[48] M. Aubry, B. Mafart, B. Donat, J.J. Brau, Brief communication: study of noncarious cervical tooth lesions in samples of prehistoric, historic, and modern populations from the South of France, Am. J. Phys. Anthropol. 121 (2003) 10–14, https://doi.org/10.1002/ajpa.10210.
[49] F. Khan, S. Shahabi, Dental cervical lesions associated with occlusal, Aust. Dent. J. (1999) 176–186.
[50] J.M. Brady, R.D. Woody, Scanning microscopy of cervical erosion, J. Am. Dent. Assoc. 94 (1977) 726–729 http://www.ncbi.nlm.nih.gov/pubmed/265335.
[51] G. McCoy, The etiology of gingival erosion, J. Oral Implantol. 10 (1982) 361–362 http://www.ncbi.nlm.nih.gov/pubmed/6961233.
[52] J. Bevenius, P. L'Estrange, S. Karlsson, G.E. Carlsson, Idiopathic cervical lesions: in vivo investigation by oral microendoscopy and scanning electron microscopy. A pilot study, J. Oral Rehabil. 20 (1993) 1–9 http://www.ncbi.nlm.nih.gov/pubmed/8429417.
[53] R.A. Bomfim, E. Crosato, L.E.N. Mazzilli, A.C. Frias, Prevalence and risk factors of non-carious cervical lesions related to occupational exposure to acid mists, Braz. Oral Res. 29 (2015) 1–8, https://doi.org/10.1590/1807-3107BOR-2015.vol29.0085.
[54] W.A.J. Smith, S. Marchan, R.N. Rafeek, The prevalence and severity of non-carious cervical lesions in a group of patients attending a university hospital in Trinidad, J. Oral Rehabil. 35 (2008) 128–134, https://doi.org/10.1111/j.1365-2842.2007.01763.x.
[55] V. Kolak, D. Pešić, I. Melih, M. Lalović, A. Nikitović, A. Jakovljević, Epidemiological investigation of non-carious cervical lesions and possible etiological factors, J. Clin. Exp. Dent. 10 (2018) e648–e656, https://doi.org/10.4317/jced.54860.
[56] D.A. Brandini, A.L.B. de Sousa, C.I. Trevisan, L.A.P. Pinelli, S.C. do Couto Santos, D. Pedrini, S.R. Panzarini, Noncarious cervical lesions and their association with toothbrushing practices: in vivo evaluation, Oper. Dent. 36 (2011) 581–589, https://doi.org/10.2341/10-152-S.
[57] A. Estafan, P.C. Furnari, G. Goldstein, E.L. Hittelman, In vivo correlation of non-carious cervical lesions and occlusal wear, J. Prosthet. Dent. 93 (2005) 221–226, https://doi.org/10.1016/j.prosdent.2004.12.012.
[58] M.A. Ommerborn, C. Schneider, M. Giraki, R. Schafer, P. Singh, M. Franz, W.H.M. Raab, In vivo evaluation of noncarious cervical lesions in sleep bruxism subjects, J. Prosthet. Dent. 98 (2007) 150–158, https://doi.org/10.1016/S0022-3913(07)60048-1.
[59] L.F. Pegoraro, J.M. Scolaro, P.C. Conti, D. Telles, T.A. Pegoraro, Noncarious cervical lesions in adults: prevalence and occlusal aspects, J. Am. Dent. Assoc. 136 (2005) 1694–1700 http://www.ncbi.nlm.nih.gov/pubmed/16383052.
[60] B.G. Smith, J.K. Knight, An index for measuring the wear of teeth, Br. Dent. J. 156 (1984) 435–438 http://www.ncbi.nlm.nih.gov/pubmed/6590081.
[61] J. Yang, D. Cai, F. Wang, D. He, L. Ma, Y. Jin, K. Que, Non-carious cervical lesions (NCCLs) in a random sampling community population and the association of NCCLs with occlusive wear, J. Oral Rehabil. 43 (2016) 960–966, https://doi.org/10.1111/joor.12445.
[62] Z.Y. Lai, Q.H. Zhi, Y. Zhou, H.C. Lin, Prevalence of non-carious cervical lesions and associated risk indicators in middle-aged and elderly populations in Southern China, Chin. J. Dent. Res. 18 (2015) 41–50.
[63] C. Walter, E. Kress, H. Götz, K. Taylor, I. Willershausen, A. Zampelis, The anatomy of non-carious cervical lesions, Clin. Oral Invest. 18 (2014) 139–146, https://doi.org/10.1007/s00784-013-0960-0.
[64] J.O. Grippo, Abfractions: a new classification of hard tissue lesions of teeth, J. Esthet. Dent. 3 (1991) 14–19 http://www.ncbi.nlm.nih.gov/pubmed/1873064.
[65] M.P. Santamaria, D. da Silva Feitosa, M.Z. Casati, F.H. Nociti, A.W. Sallum, E.A. Sallum, Randomized controlled clinical trial evaluating connective tissue graft plus resin-modified glass ionomer restoration for the treatment of gingival recession associated with non-carious cervical lesion: 2-year follow-up, J. Periodontol. 84 (2013) e1–e8, https://doi.org/10.1902/jop.2013.120447.

Online Appendix Supplement

Table S1. Details of the selected studies.

Authors, year (ID)	Subjects Characteristics (n, type of population, country)	Age (mean ± SD, range), gender distribution	NCCL definition in the study	Clinical parameters used for diagnosis	NCCL prevalence
(1) (I)	118 patients of dental faculty in São Paulo Dental population Brazil	n/a Range: ≥18 ♂: 50 (42%) ♀: 68 (58%)	Noncarious cervical lesion: Loss of dental tissues at the cementoenamel junction, in a process that does not involve bacteria (Walter et al., 2014)	Visual and tactile analysis	67.8%
(2) (II)	1320 subjects of Chengdu City General population China	n/a Range: 20-69 ♂: 660 (50%) ♀: 660 (50%)	Noncarious cervical lesion: Loss of tooth structure at the cementoenamel junction which is not related to dental caries (Aw et al., 2002)	Visual and tactile examination: Smith and Knight (21) tooth wear index	63%
(3) (III)	100 subjects of specific population in Guarulhos Worker's Health Center Reference population Brazil	Mean: 44.15 ± 0.30 Range: 20-68 ♂: 55 (55%) ♀: 45 (45%)	Noncarious cervical lesion: Non-caries related loss of tooth structure at the cementoenamel junction (Aw et al., 2002)	Visual examination: Location in the cervical third of the tooth, no caries, wedge-shaped lesion with sharp edges, or C-shaped lesion with rounded edges	76.8%
(4)(IV)	1759 subjects of Guangzhou city General population China	n/a Range: 35-44 65-74 ♂: 851 (48%) ♀: 908 (52%)	Noncarious cervical lesion: Loss of hard tissue on the cementoenamel junction of tooth which has no relationship with bacteria (Mair et al., 1992)	Visual and tactile examination: Smith and Knight (21) tooth wear index	79%◊

(5) (V)	1023 subjects of Chengdu City General population China	Mean: 46.1 Range: 20-69 ♂: 1.06 ♀: 1 (ratio)	Noncarious cervical lesion: Loss of tooth structure at the cementoenamel junction level unrelated to dental caries (Aw et al., 2002)	Visual and tactile analysis	61.7%
(6) (VI)	2160 subjects of Hubei Province General population China	n/a Range: 35-44 65-74 ♂: 1080 (50%) ♀: 1080 (50%)	Noncarious cervical lesion: Loss of tooth structure at the cementoenamel junction (Bartlett and Shah, 2006)	Visual and tactile examination: Modified Tooth wear index based on Smith and Knight	47.6%◊
(7) (VII)	102 patients referred to the Fixed and Implant Prosthodontics clinic of Thessaloniki dental school Dental population Greece	Mean: 44.1± 5.7 Range: 30-55 ♂: 54 (53%) ♀: 48 (47%)	Abfraction: visible V shaped vestibular lesions at least 2 teeth per subject	Visual examination: Clinical signs assessed on accurate diagnostic casts	24.5%
(8) (VIII)	156 patients attending an undergraduate teaching clinic at a University hospital in Trinidad Dental population Trinidad and Tobago	Mean: 40.6 Range: 16-73 ♂: 51 (33%) ♀: 105 (67%)	Noncarious cervical lesion: Loss of tooth structure at the cervical aspects of teeth (Levitch et al., 1994)	Visual examination: NCCL scored according to the dentine exposure and presence or abscence of symptoms	62.2%
(9) (IX)	394 patients referred for the Department of Restorative Dentistry and Endodontics,	n/a Range: 27-75	Noncarious cervical lesion: Loss of tooth structure at the cementoenamel junction unrelated to dental caries (Aw, 2002)	Visual examination	68.5%

	Faculty of Dentistry in Pancevo Dental population Servia	♂: 169 (43%) ♀: 225 (57%)			
(10) (X)	298 subjects of West Germany General population Germany	Mean: 54.7 Range: 50-60 ♂: 119 (40%) ♀: 179 (60%)	Root defect: non-carious and non-filled root surfaces with defects according to an abfraction, abrasion or erosion process	Visual and tactile examination	93%◊
(11) (XI)	46 patients and dental students of the School of Dental Medicine at Southern Illinois Dental population USA	Mean: 45 Range: 23-82 ♂: 14 (30%) ♀: 32 (70%)	Abfraction lesions: loading forces at the cervical level may cause the failure of the enamel prisms and result in pathologic loss of tooth structure (Grippo, 1991)	Visual examination: It was included only abfraction-type lesions appearing as sharp, wedge-shaped loss of dental structure	50%◊
(12) (XII)	873 subjects of northern Florida General population with increased risk of oral disease USA	Mean: 61.5 Range: 45-75+ ♂: 382 (44%) ♀: 491 (56%)	Root surface defect: noncarious defects	Visual and tactile examination: Noncarious defect higher than 2 mm in axial depth (it was not determined whether it was caused by abrasion, erosion or attrition)	10%
(13) (XIII)	428 subjects of Erzurum Dental population Turkey	Mean: n/a Range: 20+ ♂: 186 (43%) ♀: 242 (57%)	Abrasion: pathological wearing of dental hard tissue by mechanical forces (Levitch, 1994)	Visual examination: Lesions identifiable at the cemento enamel junction which were discoloured, noncarious, C or V- shaped and flat-floored were all taken as wedge-shaped defects	9.1%
(14) (XIV)	2707 subjects of Pomerania General population	Mean: 40.6 ± 11.1 Range: 20-59	Noncarious cervical defects: in addition to superficial erosions, hollows or notches, pronounced abfractions or wedge-shaped	Visual and tactile examination: wedge-shaped had to be clearly discernable with a probe, even apically – carious, erosive or	31.6%◊

Cross-sectional study	Germany	♂: 1 ♀: 1.1 (ratio)	defects manifest with a typical coronal borderline to the intact enamel (Bishop, 1997)	hollowed areas of hard substance loss were not counted as wedge shaped defects – the defects were recorded without gradation of lesion depth or width	
(15) (XV)	58 subjects of Araçatuba General student population Brazil	Mean: 23.6 ± 1.8 Range: 19-31 ♂: 15 (26%) ♀: 43 (74%)	Noncarious cervical lesion: the loss of dental hard tissue near the cementoenamel junction without the development of caries (Levitch, 1994)	Visual and tactile examination: losses of dental hard tissue near the CEJ without the development of caries were considered NCCL	53.5%
(16) (XVI)	299 casts of dental students of New York General student population USA	Mean: 28.9 Range: n/a ♂: n/a ♀: n/a	Noncarious cervical lesions: loss of cervical tooth structure in the absence of caries (Levitch, 1994)	Visual examination of casts: presence and severity of NCLs	33.1%
(17) (XVII)	391 subjects of Switzerland General population Switzerland	Mean: n/a Range: 26-30 46-50 ♂: n/a ♀: n/a	Dental erosion: loss of tooth substance by chemical processes not involving bacteria (Zipkin, 1949)	Visual and tactile examination: scoring system modified from Linkosalo and Markkanen	21.5%◊
(18) (XVIII)	91 subjects of Dusseldorf Dental population Germany	Mean: 28.37 ± 4.89 Range: 20-39 ♂: 33 (36%) ♀: 58 (64%)	Noncarious cervical lesion: loss of tooth substance that occurs in the absence of carious mechanisms at the cemento enamel junction of a tooth (Aw et al., 2002)	Visual examination: lesions localized in the cervical third of a tooth, free of caries, wedge-shaped, with sharp edges	30%◊
(19) (XIX)	70 subjects Dental population Brazil	Mean: n/a Range: 25-45 ♂: 35 (50%) ♀: 35 (50%)	Noncarious cervical lesions in human teeth are classified into abrasion, attrition and erosion (Pegoraro, 2005)	Visual and tactile examination: tip of the probe perpendicular to the surface – if the probe was retained by some irregularity it was considered a NCCL	88%◊

(20) (XX)	80 subjects from U. S. Army Military personnel population USA	Mean: 24.0 Range: 17-45 ♂: 66 (82%) ♀: 14 (18%)	Cervical abrasion: Loss of tooth structure in the area of cementoenamel junction resulting from abrasion, erosion and/or other noncariogenic factors (Radentz, 1976)	Visual and tactile examination: any area with any explained tooth loss regardless of suspected causes	50%◊
(21) (XXI)	1423 subjects of Stockholm General population Sweden	Mean: n/a Range: 18-65 ♂: 704 (49.5%) ♀: 719 (50.5%)	Dental abrasion: cervical abrasion of cementum and dentin caused by toothbrushing (Bergstrom and Lavstedt, 1979)	Visual examination: superficial and deep lesions were identified	31%
(22) (XXII)	261 patients of Dental Faculty and 272 employees of an industrial corporation in Oslo, totalizing 533 subjects General population Norway	Mean: n/a Range: 18-50+ ♂: n/a ♀: n/a	Tooth abrasion: loss of structure caused mainly by toothbrushing (Ervin, 1944)	Visual and tactile examination: V-shaped grooves in the gingival area of the vestibular and lingual surfaces of the theeth were described as small or large according to a depth of less or more than 1 mm	45%
(23) (XXIII)	159 male officials at Okadama Base of the Ground Self-Defense Force General population Japan	Mean: 36.2 ± 12.3 Range: 20-50+ ♂: 0 ♀: 159 (100%)	Noncarious cervical lesion: loss of tooth structure at the cemento-enamel junction that is unrelated to dental caries (Aw et al., 2002)	Visual and tactile examination: Tooth wear index was used (Smight and Knight)	49.1%
(24) (XXIV)	40 undergraduated dental students of São Paulo General population Brazil	Mean: n/a Range: 16-22 ♂: 22 (55%) ♀: 18 (45%)	Noncarious cervical lesion: loss of tooth structure on the cervical area of the tooth (Telles et al., 2006)	Visual and tactile examination: if an irregularity was felt, it was considered an NCCL even if it was localized at the cementoenamel junction	72.5%◊

Abbreviations: NCCL – noncarious cervical lesoins; N/A – not applicable.
◊ - calculated by the authors of this review based on the presented data in the selected paper

Table S2. Excluded studies after full text reading.

Exclusion criteria	Study
The prevalence of noncarious cervical lesion was not provided	Piotrowski et al., 2001 Antonelli et al., 2013 Palomino-Gómez et al., 2011 Pikdöken et al., 2011 Ahmed et al., 2009 Oginni et al., 2003 Miller et al., 2003 Aw et al., 2002 Teixeira et al., 2018 Sugita et al., 2017 Sawlani et al., 2016 Wood et al., 2009 Afolabi et al., 2012 Afolabi et al., 2013 Nieri et al., 2013 Wada et al., 2015 Mamaladze et al., 2016 Haralur et al., 2019
Age of the subjects was not provided	Naik et al., 2016 Young and Khan, 2002 Khan and Shahabi, 1999 Sadaf and Ahmad, 2014
Narrative review	Addy and Shellis, 2006 Shellis and Addy, 2014 Wiegand and Schlueter, 2014 Robertson et al., 1997
Informative article	Kontaxopoulou and Alam, 2015)
Case-control studies	Bader et al., 1996 Alvarez-Arenal et al., 2018
No assessment of NCCL	Rahiotis et al., 2013 Kopycka-Kedzierawski et al., 2017 Walls et al., 2000 da Silva et al., 2017
Age of the subjects did not match inclusion criteria	Kumar et al., 2015 Borcic et al., 2004 Zuza et al., 2019
Number of excluded papers after full reading	36

Table S3. Included studies from reference list.

Included studies from reference list of the first 11 selected papers
1. Ringelberg, 1996 2. Akgul, 2003 3. Bernhardt, 2006 4. Brandini, 2011 5. Estafan, 2005 6. Lussi, 1991 7. Ommerborn, 2007 8. Pegoraro, 2005 9. Radentz, 1976 10. Bergstrom, 1979 11. Sangnes, 1976 12. Takehara, 2008 13. Telles, 2006

Table S4. Studies included in sub analysis.

Sub analysis	Groups	Studies included
Age	Only 30+ subjects(25)	Lai, 2015 Jiang, 2011 Tsiggos, 2008 Hahn, 1999 Ringelberg, 1996
	16-30+	Yoshizaki, 2017 Yang, 2016 Bomfim, 2015 Que, 2013 Smith, 2008 Kolak, 2018 Reyes, 2009 Akgul et al., 2003 Bernardt et al., 2006 Brandini et al., 2011 Estafan et al., 2005 Lussi et al., 1991 Ommerborn et al., 2007 Pegoraro et al., 2005 Radentz et al., 1976 Bergstrom & Lavstedt., 1979 Sangnes & Gjermo, 1976 Takehara et al., 2008 Telles et al., 2006
Population	General population	Yang, 2016 Lai, 2015 Que, 2013 Jiang, 2011 Hahn, 1999 Bernardt et al., 2006 Brandini et al., 2011 Estafan et al., 2005 Lussi et al., 1991 Bergstrom & Lavstedt., 1979 Sangnes & Gjermo, 1976

		Takehara et al., 2008 Telles et al., 2006
	Dental population	Yoshizaki, 2017 Tsiggos, 2008 Smith, 2008 Kolak, 2018 Reyes, 2009 Akgul et al., 2003 Ommerborn et al., 2007 Pegoraro et al., 2005
	Specific population	Bomfim, 2015 Ringelberg et al., 1996 Radentz et al., 1976
Geographical location	South America	Yoshizaki, 2017 Bomfim, 2015 Smith, 2008 Brandini et al., 2011 Pegoraro et al., 2005 Telles et al., 2006
	North America	Reyes, 2009 Ringelberg et al., 1996 Estafan et al., 2005 Radentz et al., 1976
	Europe	Tsiggos, 2008 Kolak, 2018 Hahn, 1999 Akgul et al., 2003 Bernardt et al., 2006 Lussi et al., 1991 Ommerborn et al., 2007 Bergstrom & Lavstedt., 1979 Sangnes & Gjermo, 1976
	Asia	Yang, 2016 Lai, 2015 Que, 2013 Jiang, 2011 Takehara et al., 2008
Diagnosis	Visual and/or tactile examination	Yoshizaki, 2017 Bomfim, 2015 Que, 2013 Smith, 2008 Kolak, 2018 Hahn, 1999 Reyes, 2009 Ringelber, 1996 Akgul, 2003 Bernardt, 2006 Brandini, 2011 Estafan, 2005 Lussi, 1991 Ommerborn, 2007 Pegoraro, 2005 Radentz, 1976 Bergstrom & Lavstedt, 1979 Sangnes & Gjermo, 1976 Telles, 2006
	Smith and Knight index	Yang, 2016 Lai, 2015 Jiang, 2011

		Takehara, 2008
Definition	Aw et al., 2002	Yang, 2016 Bomfim, 2015 Que, 2013 Kolak, 2018 Ommerborn, 2007 Takehara, 2008
	Levitch et al., 1994	Smith, 2008 Akgul, 2003 Brandini, 2001 Estafan, 2005
Terms	Non carious cervical lesion	Yoshizaki, 2017 Yang, 2016 Bomfim, 2015 Lai, 2015 Que, 2013 Jiang, 2011 Smith, 2008 Kolak, 2018 Bernardt, 2006 Brandini, 2011 Estafan, 2005 Ommerborn, 2007 Pegoraro, 2005 Takehara, 2008 Telles, 2006
	Root defect	Hahn, 1999 Ringelberg, 1996
	Abrasion	Akgul, 2003 Radentz, 1976 Bergstrom & Lavstedt., 1979 Sangnes & Gjermo, 1976
	Abfraction	Tsiggos, 2008 Reyes, 2009

Table S5. Quality assessment of selected papers.

STUDY (selection ID)	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*XIII*	*XIV*	*XV*	*XVI*	*XVII*	*XVIII*	*XIX*	*XX*	*XXI*	*XXII*	*XXIII*	*XXIV*
Checklist for Analytical Cross-Sectional Studies (JBI Critical Appraisal Tool)																								
Were the criteria for inclusion in the sample clearly defined?	+	+	+	+	+	+	+	-	+	-	+	+	-	+	+	-	+	+	+	+	+	-	+	-
Were the study subjects and the setting described in detail?	-	-	-	+	-	+	+	+	-	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-
Was the exposure measured in a valid way?	+	-	+	+	+	-	+	-	-	-	+	+	-	-	-	+	-	+	-	-	+	-	-	-
Was the exposure measured in a reliable way?	+	+	+	-	+	-	+	-	+	-	-	+	-	-	-	-	-	-	+	-	-	-	-	-
Were objective, standard criteria used for measurement of the condition?	+	+	+	-	+	-	-	+	+	+	+	-	+	+	-	-	+	-	-	-	+	-	+	-
Were confounding factors identified?	+	+	-	+	+	+	-	-	+	+	+	-	-	+	-	-	-	-	-	+	+	+	+	-
Were strategies to deal with confounding factors stated?	-	-	-	+	+	-	-	-	-	+	+	-	-	+	-	-	-	-	-	-	+	-	+	-
Were the outcomes measured in a valid way?	+	+	+	+	+	+	+	+	-	+	+	-	-	+	-	+	+	+	+	-	-	+	+	+
Were the outcomes measured in a reliable way?	+	-	+	-	+	+	+	-	+	+	-	+	-	+	-	-	+	-	-	-	-	-	-	-
Was appropriate statistical analysis used?	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+
RISK OF BIAS	**L**	**M**	**M**	**M**	**L**	**M**	**M**	**H**	**S**	**M**	**L**	**S**	**H**	**L**	**H**	**H**	**S**	**S**	**S**	**H**	**M**	**H**	**M**	**H**

Criteria were designated for each domain of methodology, internal validity, external validity and statistical methods. Each aspect of the score list was given a rating of ‘+’ for an informative description of the item at issue and a study design meeting the quality standard, ‘- ‘for an informative description without a study design that met the quality standard, and ‘?’ for insufficient information.

+ = yes
- = no
? = not specified/unclear
H – high risk of bias = 0-40%*
S – substantial risk of bias = 40-60%
M - moderate risk of bias = 60-80%
L – low risk of bias = 80-100%
(61)

Table S6. Guidelines of PRISMA.

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	2
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	3
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	3
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	3

Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	3
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	3
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	3
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	3
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	3
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	4
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	5
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	5
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	6
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	6
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	6
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	5
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	5-6
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	7-8

Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	7-8
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	8
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	1

Table S7. MOOSE checklist.

Item No	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	2
2	Hypothesis statement	2
3	Description of study outcome(s)	2
4	Type of exposure or intervention used	2
5	Type of study designs used	2
6	Study population	2
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	3
8	Search strategy, including time period included in the synthesis and key words	3
9	Effort to include all available studies, including contact with authors	3
10	Databases and registries searched	3

11	Search software used, name and version, including special features used (eg, explosion)	N.A.
12	Use of hand searching (eg, reference lists of obtained articles)	3
13	List of citations located and those excluded, including justification	3
14	Method of addressing articles published in languages other than English	3
15	Method of handling abstracts and unpublished studies	3
16	Description of any contact with authors	N.A.
Reporting of methods should include		
17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	4
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	N. A.
19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	N. A.
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	N. A.
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	4
22	Assessment of heterogeneity	4
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	4-5
24	Provision of appropriate tables and graphics	Appendix
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	Online Suppl
26	Table giving descriptive information for each study included	Online Supp
27	Results of sensitivity testing (eg, subgroup analysis)	Table 2

28	Indication of statistical uncertainty of findings	N. A.

Modified from Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA 2000;283:2008–12

Reference List. References for online supportive information.

1. Yoshizaki KT, Francisconi-dos-Rios LF, Sobral MAP, Aranha ACC, Mendes FM, Scaramucci T. Clinical features and factors associated with non-carious cervical lesions and dentin hypersensitivity. J Oral Rehabil [Internet]. 2017;44(2):112–8. Available from: http://doi.wiley.com/10.1111/joor.12469
2. Yang J, Cai D, Wang F, He D, Ma L, Jin Y, et al. Non-carious cervical lesions (NCCLs) in a random sampling community population and the association of NCCLs with occlusive wear. J Oral Rehabil. 2016;43(12):960–6.
3. BOMFIM RA, CROSATO E, MAZZILLI LEN, FRIAS AC. Prevalence and risk factors of non-carious cervical lesions related to occupational exposure to acid mists. Braz Oral Res [Internet]. 2015;29(1):1–8. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-83242015000100280&lng=en&tlng=en
4. Lai ZY, Zhi QH, Zhou Y, Lin HC. Prevalence of Non-carious Cervical Lesions and Associated Risk Indicators in Middle-aged and Elderly Populations in Southern China. Chinese J Dent Res. 2015;18(1):41–50.
5. Que K, Guo B, Jia Z, Chen Z, Yang J, Gao P. A cross-sectional study: Non-carious cervical lesions, cervical dentine hypersensitivity and related risk factors. J Oral Rehabil. 2013;40(1):24–32.
6. Jiang H, Du MQ, Huang W, Peng B, Bian Z, Tai BJ. The prevalence of and risk factors for non-carious cervical lesions in adults in Hubei Province, China. Community Dent Health [Internet]. 2011 Mar;28(1):22–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21485230
7. Tsiggos N, Tortopidis D, Hatzikyriakos A, Menexes G. Association between self-reported bruxism activity and occurrence of dental attrition, abfraction, and occlusal pits on natural teeth. J Prosthet Dent. 2008;100(1):41–6.
8. Smith WAJ, Marchan S, Rafeek RN. The prevalence and severity of non-carious cervical lesions in a group of patients attending a university hospital in Trinidad. J Oral Rehabil. 2008;35(2):128–34.
9. Kolak V, Pešić D, Melih I, Lalović M, Nikitović A, Jakovljević A. Epidemiological investigation of non-carious cervical lesions and possible etiological factors. J Clin Exp Dent. 2018;10(7):e648–56.
10. Hahn P, Reinhardt D, Schaller HG, Hellwig E. Root lesions in a group of 50-60

year-old Germans related to clinical and social factors. Clin Oral Investig. 1999;3(4):168–74.

11. Reyes E, Hildebolt C, Langenwalter E, Miley D. Abfractions and Attachment Loss in Teeth With Premature Contacts in Centric Relation: Clinical Observations. J Periodontol [Internet]. 2009;80(12):1955–62. Available from: http://www.joponline.org/doi/10.1902/jop.2009.090149
12. Ringelberg ML, Gilbert GH, Antonson DE, Dolan TA, Legler DW, Foerster U, et al. Root caries and root defects in urban and rural adults: the Florida Dental Care Study. J Am Dent Assoc [Internet]. 1996 Jul;127(7):885–91. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8754463
13. Akgül HM, Akgül N, Karaoglanoglu S, Ozdabak N. A survey of the correspondence between abrasions and tooth brushing habits in Erzurum, Turkey. Int Dent J [Internet]. 2003 Dec;53(6):491–5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14725378
14. Bernhardt O, Gesch D, Schwahn C, Mack F, Meyer G, John U, et al. Epidemiological evaluation of the multifactorial aetiology of abfractions. J Oral Rehabil [Internet]. 2006 Jan;33(1):17–25. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16409512
15. Brandini DA, de Sousa ALB, Trevisan CI, Pinelli LAP, do Couto Santos SC, Pedrini D, et al. Noncarious cervical lesions and their association with toothbrushing practices: in vivo evaluation. Oper Dent [Internet]. 2011;36(6):581–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21913861
16. Estafan A, Furnari PC, Goldstein G, Hittelman EL. In vivo correlation of noncarious cervical lesions and occlusal wear. J Prosthet Dent [Internet]. 2005 Mar;93(3):221–6. Available from: http://linkinghub.elsevier.com/retrieve/pii/S002239130400825X
17. Lussi A, Schaffner M, Hotz P, Suter P. Dental erosion in a population of Swiss adults. Community Dent Oral Epidemiol [Internet]. 1991 Oct;19(5):286–90. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1742995
18. 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. J Prosthet Dent [Internet]. 2007 Aug;98(2):150–8. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0022391307600481

19. Pegoraro LF, Scolaro JM, Conti PC, Telles D, Pegoraro TA. Noncarious cervical lesions in adults: prevalence and occlusal aspects. J Am Dent Assoc [Internet]. 2005 Dec;136(12):1694–700. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16383052
20. Radentz WH, Barnes GP, Cutright DE. A Survey of Factors Possibly Associated With Cervical Abrasion of Tooth Surfaces. J Periodontol [Internet]. 1976 Mar;47(3):148–54. Available from: http://doi.wiley.com/10.1902/jop.1976.47.3.148
21. Bergström J, Lavstedt S. An epidemiologic approach to toothbrushing and dental abrasion. Community Dent Oral Epidemiol [Internet]. 1979 Feb;7(1):57–64. Available from: http://www.ncbi.nlm.nih.gov/pubmed/282958
22. Sangnes G, Gjermo P. Prevalence of oral soft and hard tissue lesions related to mechanical toothcleansing procedures. Community Dent Oral Epidemiol [Internet]. 1976 Mar;4(2):77–83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1062255
23. Takehara J, Takano T, Akhter R, Morita M. Correlations of noncarious cervical lesions and occlusal factors determined by using pressure-detecting sheet. J Dent [Internet]. 2008 Oct;36(10):774–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18597913
24. Telles D, Pegoraro LF, Pereira JC. Incidence of noncarious cervical lesions and their relation to the presence of wear facets. J Esthet Restor Dent [Internet]. 2006;18(4):178–83; discussion 184. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16911416
25. Piotrowski BT, Gillette WB, Hancock EB. Examining the prevalence and characteristics of abfractionlike cervical lesions in a population of U.S. veterans. J Am Dent Assoc [Internet]. 2001;132(12):1694–701. Available from: http://dx.doi.org/10.14219/jada.archive.2001.0122
26. Antonelli JR, Hottel TL, Brandt R, Scarbecz M, Patel T. The role of occlusal loading in the pathogenesis of non-carious cervical lesions. Am J Dent. 2013;26(2):86–92.
27. Palomino-Gómez SP, Jeremias F, Finoti LS, Paredes-Coz G, Raveli DB. Influence of lateral excursion on vestibular cervical dental abfraction. Acta Odontol Latinoam [Internet]. 2011;24(3):283–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22550823

28. Pikdöken L, Akca E, Gürbüzer B, Aydil B, Taşdelen B. Cervical wear and occlusal wear from a periodontal perspective. J Oral Rehabil [Internet]. 2011 Feb;38(2):95–100. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20678102
29. Ahmed H, Durr-E-Sadaf, Rahman M. Factors associated with Non-Carious Cervical Lesions (NCCLs) in teeth. J Coll Physicians Surg Pak [Internet]. 2009 May;19(5):279–82. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19409158
30. Oginni AO, Olusile AO, Udoye CI. Non-carious cervical lesions in a Nigerian population: Abrasion or abfraction? Int Dent J. 2003;53(5):275–9.
31. Miller N, Penaud J, Ambrosini P, Bisson-Boutelliez C, Briançon S. Analysis of etiologic factors and periodontal conditions involved with 309 abfractions. J Clin Periodontol. 2003;30(9):828–32.
32. Aw TC, Lepe X, Johnson GH, Mancl L. Characteristics of noncarious cervical lesions: a clinical investigation. J Am Dent Assoc [Internet]. 2002 Jun;133(6):725–33. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12083648
33. Teixeira DNR, Zeola LF, Machado AC, Gomes RR, Souza PG, Mendes DC, et al. Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: A cross-sectional study. J Dent. 2018;76.
34. Sugita I, Nakashima S, Ikeda A, Burrow MF, Nikaido T, Kubo S, et al. A pilot study to assess the morphology and progression of non-carious cervical lesions. J Dent [Internet]. 2017;57(2017):51–6. Available from: http://dx.doi.org/10.1016/j.jdent.2016.12.004
35. Sawlani K, Lawson NC, Burgess JO, Lemons JE, Kinderknecht KE, Givan DA, et al. Factors influencing the progression of noncarious cervical lesions: A 5-year prospective clinical evaluation. J Prosthet Dent [Internet]. 2016;115(5):571–7. Available from: http://dx.doi.org/10.1016/j.prosdent.2015.10.021
36. Wood ID, Kassir ASA, Brunton PA. Effect of Lateral Excursive Movements on the Progression of Abfraction Lesions. Oper Dent [Internet]. 2009;34(3):273–9. Available from: http://www.jopdentonline.org/doi/10.2341/08-100
37. Afolabi AO, Shaba OP, Adegbulugbe IC. Distribution and characteristics of non carious cervical lesions in an adult Nigerian population. Nig Q J Hosp Med

[Internet]. 2012;22(1):1–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23175871
38. Afolabi AO, Shaba OP, Adegbulugbe IC. Clinical investigation of patient related factors in non carious cervical lesions. Nig Q J Hosp Med [Internet]. 2013;23(2):129–34. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24579510
39. Nieri M, Pini Prato GP, Giani M, Magnani N, Pagliaro U, Roberto R. Patient perceptions of buccal gingival recessions and requests for treatment. J Clin Periodontol. 2013;40(7):707–12.
40. Wada I, Shimada Y, Ikeda M, Sadr A, Nakashima S, Tagami J, et al. Clinical assessment of non carious cervical lesion using swept-source optical coherence tomography. J Biophotonics. 2015;8(10):846–54.
41. Mamaladze M, Khutsishvili L, Zarkua E. DISTRIBUTION OF CARIOUS AND NON-CARIOUS CERVICAL LESIONS AND GINGIVAL RECESSION AT AGE RELATED ASPECTS. Georgian Med News [Internet]. 2016 Jul;(256–257):18–23. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27661270
42. Haralur, Alqahtani, AlMazni, Alqahtani. Association of Non-Carious Cervical Lesions with Oral Hygiene Habits and Dynamic Occlusal Parameters. Diagnostics [Internet]. 2019 Apr 12;9(2):43. Available from: https://www.mdpi.com/2075-4418/9/2/43
43. Naik VK, Jacob CA, Nainar DA. Assessment of non-carious root surface defects in areas of gingival recession: A descriptive study. J Clin Exp Dent. 2016;18(4):397–402.
44. Young WG, Khan F. Sites of dental erosion are saliva dependent. J Oral Rehabil. 2002;29:35–43.
45. Khan F, Shahabi S. Dental cervical lesions associated with occlusal. Aust Dent J. 1999;(3):176–86.
46. Sadaf D, Ahmad Z. Role of brushing and occlusal forces in non-carious cervical lesions (NCCL). Int J Biomed Sci. 2014;10(4):265–8.
47. Addy M, Shellis RP. Interaction between Attrition,Abrasion and Erosion in Tooth Wear. Dent Eros [Internet]. 2006;20:17–31. Available from: https://www.karger.com/Article/FullText/93348
48. Shellis RP, Addy M. The Interactions between Attrition, Abrasion and Erosion in Tooth Wear. In 2014. p. 32–45. Available from:

https://www.karger.com/Article/FullText/359936
49. Wiegand A, Schlueter N. The Role of Oral Hygiene: Does Toothbrushing Harm? In 2014. p. 215–9. Available from: https://www.karger.com/Article/FullText/360379
50. Robertson PB, Walsh MM, Greene JC. Oral effects of smokeless tobacco use by professional baseball players. Adv Dent Res [Internet]. 1997 Sep;11(3):307–12. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9524430
51. Kontaxopoulou I, Alam S. Risk Assessment for Tooth Wear. Prim Dent J [Internet]. 2015;4(3):25–9. Available from: http://openurl.ingenta.com/content/xref?genre=article&issn=2050-1684&volume=4&issue=3&spage=25
52. Bader JD, McClure F, Scurria MS, Shugars DA, Heymann HO. Case-control study of non-carious cervical lesions. Community Dent Oral Epidemiol [Internet]. 1996 Aug;24(4):286–91. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8871039
53. Alvarez-Arenal A, Alvarez-Menendez L, Gonzalez-Gonzalez I, Alvarez-Riesgo JA, Brizuela-Velasco A, DeLlanos-Lanchares H. Non-carious cervical lesions and risk factors: a case-control study. J Oral Rehabil [Internet]. 2018 Sep 25; Available from: http://www.ncbi.nlm.nih.gov/pubmed/30252966
54. Rahiotis C, Polychronopoulou A, Tsiklakis K, Kakaboura A. Cervical dentin hypersensitivity: A cross-sectional investigation in Athens, Greece. J Oral Rehabil. 2013;40(12):948–57.
55. Kopycka-Kedzierawski DT, Meyerowitz C, Litaker MS, Chonowski S, Heft MW, Gordan V V., et al. Management of Dentin Hypersensitivity by National Dental Practice-Based Research Network practitioners: Results from a questionnaire administered prior to initiation of a clinical study on this topic. BMC Oral Health [Internet]. 2017;17(1):1–7. Available from: http://dx.doi.org/10.1186/s12903-017-0334-0
56. Walls AWG, Silver PT, Steele JG. Impact of treatment provision on the epidemiological recording of root caries. Eur J Oral Sci. 2000;108(1):3–8.
57. da Silva AMBR, Valencise Magri L, da Silva MAMR, Sousa Neto MD de. Are the bite force and electromyographic activity altered in muscle TMD patients with abfraction lesions? Cranio - J Craniomandib Pract [Internet]. 2017;9634(November):1–7. Available from:

http://doi.org/10.1080/08869634.2017.1407116

58. Kumar S, Kumar A, Debnath N, Kumar A, K. Badiyani B, Basak D, et al. Prevalence and risk factors for non-carious cervical lesions in children attending special needs schools in India. J Oral Sci [Internet]. 2015;57(1):37–43. Available from: https://www.jstage.jst.go.jp/article/josnusd/57/1/57_37/_article

59. Borcic J, Anic I, Urek MM, Ferreri S. The prevalence of non-carious cervical lesions in permanent dentition. J Oral Rehabil [Internet]. 2004;31(2):117–23. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15009594

60. Zuza A, Racic M, Ivkovic N, Krunic J, Stojanovic N, Bozovic D, et al. Prevalence of non-carious cervical lesions among the general population of the Republic of Srpska, Bosnia and Herzegovina. Int Dent J [Internet]. 2019 Feb 7;idj.12462. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/idj.12462

61. Sälzer S, Slot DE, Van der Weijden FA, Dörfer CE. Efficacy of inter-dental mechanical plaque control in managing gingivitis - a meta-review. J Clin Periodontol [Internet]. 2015 Apr;42:S92–105. Available from: http://doi.wiley.com/10.1111/jcpe.12363

62. Teixeira DNR, Thomas RZ, Soares PV, Cune MS, Gresnigt MMM, Slot DE. Prevalence of noncarious cervical lesions among adults: A systematic review. J Dent [Internet]. 2020 Apr;95:103285. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571220300191

63. Grippo JO, Simring M, Coleman TA. Abfraction, abrasion, biocorrosion, and the enigma of noncarious cervical lesions: A 20-year perspective. J Esthet Restor Dent. 2012;24(1):10–23.

64. Grippo JO, Simring M, Schreiner S. Attrition, abrasion, corrosion and abfraction revisited: A new perspective on tooth surface lesions. J Am Dent Assoc [Internet]. 2004;135(8):1109–18. Available from: http://dx.doi.org/10.14219/jada.archive.2004.0369

65. Bartlett DW, Shah P. A Critical Review of Non-carious Cervical (Wear) Lesions and the Role of Abfraction, Erosion, and Abrasion. J Dent Res [Internet]. 2006 Apr 13;85(4):306–12. Available from: http://journals.sagepub.com/doi/10.1177/154405910608500405

66. Bartlett D. Etiology and prevention of acid erosion. Compend Contin Educ Dent [Internet]. 2009;30(9):616–20. Available from:

http://www.ncbi.nlm.nih.gov/pubmed/19998728
67. Barron RP, Carmichael RP, Marcon MA, Sàndor GKB. Dental erosion in gastroesophageal reflux disease. J Can Dent Assoc [Internet]. 2003 Feb;69(2):84–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12559056
68. Dawes C. What is the critical pH and why does a tooth dissolve in acid? J Can Dent Assoc [Internet]. 2003 Dec;69(11):722–4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14653937
69. Heasman PA, Holliday R, Bryant A, Preshaw PM. Evidence for the occurrence of gingival recession and non-carious cervical lesions as a consequence of traumatic toothbrushing. J Clin Periodontol. 2015;42(S16):S237–55.
70. Auad S, Moynihan P. Diet and dental erosion. Quintessence Int [Internet]. 2007 Feb;38(2):130–3. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17263152
71. Kitchens M, Owens B. Effect of Carbonated Beverages, Coffee, Sports and High Energy Drinks, and Bottled Water on the in vitro Erosion Characteristics of Dental Enamel. J Clin Pediatr Dent [Internet]. 2007 Apr 1;31(3):153–9. Available from: https://meridian.allenpress.com/jcpd/article/31/3/153/78456/Effect-of-Carbonated-Beverages-Coffee-Sports-and
72. Wongkhantee S, Patanapiradej V, Maneenut C, Tantbirojn D. Effect of acidic food and drinks on surface hardness of enamel, dentine, and tooth-coloured filling materials. J Dent [Internet]. 2006 Mar;34(3):214–20. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571205001223
73. Bartlett DW, Evans DF, Anggiansah A, Smith BG. A study of the association between gastro-oesophageal reflux and palatal dental erosion. Br Dent J [Internet]. 1996 Aug 24;181(4):125–31. Available from: http://www.nature.com/articles/4809187
74. Moazzez R, Bartlett D, Anggiansah A. Dental erosion, gastro-oesophageal reflux disease and saliva: how are they related? J Dent [Internet]. 2004 Aug;32(6):489–94. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571204000661
75. Rees JS. The biomechanics of abfraction. Proc Inst Mech Eng Part H J Eng Med [Internet]. 2006 Jan 17;220(1):69–80. Available from: http://journals.sagepub.com/doi/10.1243/095441105X69141

76. BORCIC J, ANIC I, SMOJVER I, CATIC A, MILETIC I, RIBARIC SP. 3D finite element model and cervical lesion formation in normal occlusion and in malocclusion. J Oral Rehabil [Internet]. 2005 Jul;32(7):504–10. Available from: http://doi.wiley.com/10.1111/j.1365-2842.2005.01455.x
77. Grippo JO. Noncarious cervical lesions: the decision to ignore or restore. J Esthet Dent [Internet]. 1992;4 Suppl:55–64. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1298328
78. Briggs Institute Joanna T. Joanna Briggs Institute Reviewer's Manual. Adelaide: The Joanna Briggs Institute; 2014.
79. Rusu Olaru A, Popescu MR, Dragomir LP, Rauten AM. Clinical Study on Abfraction Lesions in Occlusal Dysfunction. Curr Heal Sci J [Internet]. 45(4):390–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/32110441
80. Rusu Olaru A, Popescu MR, Dragomir LP, Popescu DM, Arsenie CC, Rauten AM. Identifying the Etiological Factors Involved in the Occurrence of Non-Carious Lesions. Curr Heal Sci J [Internet]. 45(2):227–34. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31624652
81. Teixeira DNR, Zeola LF, Machado AC, Gomes RR, Souza PG, Mendes DC, et al. Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: a cross-sectional study. J Dent [Internet]. 2018;(June):1–5. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571218301805%0Ahttp://www.ncbi.nlm.nih.gov/pubmed/29940290
82. Marinescu IR, Popescu SM, Răghici EC, Scrieciu M, Mercuț V, Turcu AA, et al. Etiological Aspects of Noncarious Dental Lesions. Curr Heal Sci J [Internet]. 43(1):54–61. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30595855
83. Antonelli JR, Hottel TL, Garcia-Godoy F. Abfraction lesions--where do they come from? A review of the literature. J Tenn Dent Assoc [Internet]. 2013;93(1):11–4. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=23909084%5Cnhttp://www.ncbi.nlm.nih.gov/pubmed/23909084
84. Brandini DA, Trevisan CL, Panzarini SR, Pedrini D. Clinical evaluation of the association between noncarious cervical lesions and occlusal forces. J Prosthet Dent [Internet]. 2012 Nov;108(5):298–303. Available from:

http://www.ncbi.nlm.nih.gov/pubmed/23107237

85. Hirata Y, Yamamoto T, Kawagoe T, Sasaguri K, Sato S. Relationship between occlusal contact pattern and non-carious cervical lesions among male adults. Int J Stomatol Occlusion Med [Internet]. 2010 Mar 23;3(1):10–4. Available from: http://link.springer.com/10.1007/s12548-010-0039-3

86. telles daniel, Pegoraro luiz fernando, Pereira jose carlos. Incidence of Noncarious Cervical Lesions and Their Relation to the Presence of Wear Facets. J Esthet Restor Dent [Internet]. 2006 Jul;18(4):178–83. Available from: http://doi.wiley.com/10.1111/j.1708-8240.2006.00015.x

87. TELLES D, PEGORARO LF, PEREIRA JC. Prevalence of Noncarious Cervical Lesions and Their Relation to Occlusal Aspects: A Clinical Study. J Esthet Restor Dent [Internet]. 2000 Jan;12(1):10–5. Available from: http://doi.wiley.com/10.1111/j.1708-8240.2000.tb00193.x

88. Guyatt GH, Oxman AD, Montori V, Vist G, Kunz R, Brozek J, et al. GRADE guidelines: 5. Rating the quality of evidence—publication bias. J Clin Epidemiol [Internet]. 2011 Dec;64(12):1277–82. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0895435611001818

89. Smith BG, Knight JK. An index for measuring the wear of teeth. Br Dent J [Internet]. 1984 Jun 23;156(12):435–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/6590081

90. Smith BG, Robb ND. The prevalence of toothwear in 1007 dental patients. J Oral Rehabil [Internet]. 1996 Apr;23(4):232–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8730269

91. SENNA P, DEL BEL CURY A, RÖSING C. Non-carious cervical lesions and occlusion: a systematic review of clinical studies. J Oral Rehabil [Internet]. 2012 Jun;39(6):450–62. Available from: http://doi.wiley.com/10.1111/j.1365-2842.2012.02290.x

92. Brandini DA, de Sousa ALB, Trevisan CI, Pinelli LAP, do Couto Santos SC, Pedrini D, et al. Noncarious cervical lesions and their association with toothbrushing practices: in vivo evaluation. Oper Dent [Internet]. 36(6):581–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21913861

93. Khan F, Young WG, Shahabi S, Daley TJ. Dental cervical lesions associated with occlusal erosion and attrition. Aust Dent J [Internet]. 1999 Sep;44(3):176–86. Available from: http://doi.wiley.com/10.1111/j.1834-7819.1999.tb00219.x

94. Azevedo AM de, Panzeri H, Prado CJ do, De-Mello JDB, Soares CJ, Fernandes-Neto AJ. Assessment in vitro of brushing on dental surface roughness alteration by laser interferometry. Braz Oral Res [Internet]. 2008 Mar;22(1):11–7. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-83242008000100003&lng=en&tlng=en

95. Litonjua LA, Andreana S, Bush PJ, Tobias TS, Cohen RE. Wedged cervical lesions produced by toothbrushing. Am J Dent [Internet]. 2004 Aug;17(4):237–40. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15478482

96. Faye B, Kane AW, Sarr M, Lo C, Ritter A V, Grippo JO. Noncarious cervical lesions among a non-toothbrushing population with Hansen's disease (leprosy): initial findings. Quintessence Int [Internet]. 2006 Sep;37(8):613–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16922020

97. Pashley DH. How can sensitive dentine become hypersensitive and can it be reversed? J Dent [Internet]. 2013 Jul;41:S49–55. Available from: https://linkinghub.elsevier.com/retrieve/pii/S030057121370006X

98. da Silva AMBR, Valencise Magri L, da Silva MAMR, Sousa Neto MD de. Are the bite force and electromyographic activity altered in muscle TMD patients with abfraction lesions? CRANIO® [Internet]. 2019 May 4;37(3):168–74. Available from: https://www.tandfonline.com/doi/full/10.1080/08869634.2017.1407116

99. Igarashi Y, Yoshida S, Kanazawa E. The prevalence and morphological types of non-carious cervical lesions (NCCL) in a contemporary sample of people. Odontology. 2017;105(4):443–52.

100. Srisilapanan P, Jindarat M, Roseman J. The Prevalence and Severity of Tooth Wear in Type 2 Diabetic Patients. Int J Dent [Internet]. 2018 Dec 11;2018:1–5. Available from: https://www.hindawi.com/journals/ijd/2018/3608158/

1.

Capítulo 2

Original research: ***Risk factors associated with noncarious cervical lesions: A systematic review***

Teixeira DNR, Thomas RZ, Soares PV, Cune MS, Slot DE, Gresnigt MMM.

RISK FACTORS ASSOCIATED WITH NONCARIOUS CERVICAL LESIONS: A SYSTEMATIC REVIEW

Short title: Risk factors of noncarious cervical lesions

Daniela Navarro Ribeiro Teixeira[1,2]; Renske Z. Thomas[2]; Paulo Vinicius Soares[1]; Marco. S. Cune[2,3,4]; Dagmar Else Slot[5]; Marco M. M. Gresnigt[2,6].

[1]Federal University of Uberlândia, NCCL Research Group, Department of Restorative Dentistry, School of Dentistry, Uberlândia, Brazil.

[2]University Medical Center Groningen, University of Groningen, Center for Dentistry and Oral Hygiene, Department of Restorative Dentistry and Biomaterials, Groningen, The Netherlands.

[3]St. Antonius Hospital, Department of Oral Maxillofacial Surgery, Prosthodontics and Special Dental Care, Nieuwegein, the Netherlands.

[4]University of Utrecht, University Medical Center Utrecht, Department of Oral Maxillofacial Surgery, Prosthodontics and Special Dental Care, Utrecht, the Netherlands.

[5]Academic Centre for Dentistry Amsterdam (ACTA), Department of Periodontology, University of Amsterdam and VU Universiteit, Amsterdam, The Netherlands

[6]Martini Hospital, Department of Special Dental Care, Groningen, The Netherlands.

Corresponding author:

Paulo Vinicius Soares

Federal University of Uberlândia, NCCL Research Group, Department of Restorative Dentistry, School of Dentistry, Uberlândia, Brazil

Email address: paulovsoares@yahoo.com.br

RISK FACTORS ASSOCIATED WITH NONCARIOUS CERVICAL LESIONS: A SYSTEMATIC REVIEW

ABSTRACT

Objectives: This study aims to systematically review the literature on the risk factors associated with noncarious cervical lesions (NCCLs).
Methods: The protocol of this systematic review was prepared according to PRISMA and MOOSE guidelines. The MEDLINE-PubMed and Cochrane-CENTRAL databases were searched. Relevant published papers that provided information regarding any risk factors associated with NCCLs were included.
Results: The initial search identified 329 titles and abstracts, resulting in 26 that met the eligibility criteria. 13 articles were added from reference list, totalizing 39 to be analyzed, of which only 23% were considered to have a low risk of bias. An association with dentin hypersensitivity and gingival recession was found in 21% and 15%. Only 5% found an association with both alterations concomitantly. Occlusal trauma, age and toothbrushing were the most cited risk factors among the studies, with 41%, 39% and 36%, respectively. Parafunctional habits and exposure to intrinsic or extrinsic acid totalized 21%, 8% and 21% of the studies.
Conclusion: This systematic review found factors in different categories to be associated with NCCLs such as age, frequency and vigorousness of toothbrushing, hardness of toothbrush, exposure to intrinsic and extrinsic acids, parafunctional habits and occlusal trauma. Despite the lack of standardization of methods of NCCL and risk factors assessment, its multifactorial etiology is clearly presented on this review.

INTRODUCTION

Noncarious cervical lesions (NCCL) are defined as a tooth structure loss at the cemento-enamel junction (CEJ) which is not associated with the presence of bacteria (32). It has a worldwide prevalence of 46.7% which is higher in older populations, according to a recent systematic review (62). Several studies report its multifactorial etiology (63–65), which associates friction (attrition and abrasion), biocorrosion (63) or erosion (66–68), and occlusal stress (abfraction), although no consensus of the role of each process has been found to date.

Abrasion is mainly associated with toothbrushing and biting hard objects as pens, pencils or even nails (64), although there is one systematic review which suggested that there is not enough data to support the association between toothbrushing and NCCL or gingival recession (GR) (69). Biocorrosion/erosion is related with extrinsic (food, carbonated soft drinks, fruit juice, wine, vinegar, work environment, etc.) (70–72) and intrinsic acids (gastroesophaseal reflux disease, among others) (73,74). Studies conducted on the role of occlusal stress seem to show that occlusal interferences, premature contacts, habits of bruxism and clenching may produce high load forces (75,76) and when concentrated on the cervical region, might lead to NCCLs.

They are also often associated with GR and/or cervical dentin hypersensitivity (CDH) (1,22,33,77). This is probably due to the cervical exposure and biofilm accumulation that it might bring. Although there is no clear evidence of the exact association between the presence of biofilm and NCCL (33), some authors believe that its acidity acts as an endogenous biocorrosive factor (63), which favors the progression of NCCL.

Although several authors confirm the multifactorial nature of the disease, the etiology of NCCLs is still not clear. Epidemiological studies on risk factors are being conducted all over the world with the attempt to understand the process of formation and progression of NCCL. These results are of great importance because, besides describing specific risk factors, they can also point out preventive measures and ways of controlling the disease. This study therefore aims to systematically review the available literature to identify the main risk factors which contribute to the formation and progression of noncarious cervical lesions, besides punctuating its association with other alterations such as gingival recession and/or dentin hypersensitivity.

MATERIALS AND METHODS

The protocol of this systematic review was prepared according to MOOSE guidelines (Table S11). The Focused question was: "What are the risk factors of NCCLs?" Therefore, two Internet sources were used to search for appropriate papers that satisfied the study purpose. For details regarding the search terms used, see table 1 and for search, screening and selection procedure see Figure 1.

2.1 Search strategy

Two internet sources were used to search for appropriate papers that satisfied the study purpose: the National Library of Medicine, Washington, DC (MEDLINE-PubMed) and the Cochrane Central Register of Controlled Trials (CENTRAL). For this comprehensive search, databases were searched for eligible studies up to and including September 2020 according to the following criteria: studies in the English language; human subjects ≥16years old; diagnosed with NCCL as assessed by dental care professionals; cross-sectional, randomized clinical trials or cohort studies, reporting the outcome: risk factors of noncarious cervical lesions.

2.2 Screening and selection

Two reviewers (DNRT and RZT) independently screened the titles and abstracts for eligible papers. If eligible aspects were present in the title, the paper was selected for further reading. If not, the abstract and key words were read in detail to screen for suitability. After selection, the two reviewers read the full-text papers in detail. Any disagreement between the two was resolved by additional discussion. If disagreement persisted, the judgment of a third reviewer (MMG) was decisive. The papers that fulfilled all of the selection criteria were processed for data extraction. For those papers that provided insufficient data to be included in the analysis, the first and/or corresponding author was contacted in an attempt to obtain additional data.

2.3 Data extraction and methodological quality assessment

From the papers that met the selection criteria, data were processed for further analyses. This was done by two independent reviewers (DNRT and RZT). The primary interest was the risk factors of NCCL. The heterogeneity across studies was detailed according to the following factors: study design, subjects' characteristics, age and gender distribution, diagnostic criteria for NCCL, presence of any association with gingival recession or dentin hypersensitivity, and risk factor assessed like oral hygiene habits, diet, presence of gastric diseases, parafunctional habits, premature contacts, among others (online appendix S1 and S2).

2.3. Risk of bias

Subsequently, the methodological qualities of the included studies were assessed according to the quality criteria that were obtained from the checklist for analytical cross sectional studies (S6), cohort (S7), randomized clinical trials (S8) and case-control studies (S9) of Johanna Briggs Institute statement (JBI Summary) (78). In short, when sources of data and clear methods of diagnose, description or consideration of potential sources of bias, calibration or training of examiners, valid and reliable sources of assessment of each risk factor and appropriate statistics were used, the study was classified as having a low risk of bias.

2.4 Data analysis

Data was pooled into a descriptive percentage table as a quantitative sub-analysis for age group, type of population, geographical location, diagnosis of NCCLs, any association with dentin hypersensitivity or gingival recession and all the risk factors assessed. For a detailed overview of which studies were used per analysis, see Online Appendix S5.

2.5 Grading

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) system,) was used to appraise the evidence emerging from this review, as proposed by the GRADE working group (2014). The three mentioned reviewers rated the body of evidence; any disagreement was resolved after additional discussion.

RESULTS

3.1. Search results

The search identified 329 unique papers. The screening of titles and abstracts resulted in 35 full-text articles of which seven papers, after full text reading, were excluded for not meeting the eligibility criteria (online appendix S3), which resulted in 26 included studies. Subsequently, all reference lists of the selected studies were hand-searched for additional published work that could possibly meet the eligibility criteria of the study. 13 additional studies were included this way (online appendix S4), totalizing 39 articles (1,2,14,15,18–20,22,23,25,27,28,3,30–32,35,36,38,42,52,53,57,4,79–87,5–9,11) to be analyzed (Figure 1).

3.2. Characteristics of selected studies

Evaluation of the included studies showed considerable heterogeneity. The extracted data about study design, characteristics of the studied population, geographical location of the study, diagnostic methods for NCCL, association with dentin hypersensitivity and/or gingival recession and risk factors assessed are presented in the online appendix.

The range of the included number of participants within studies was 20-2160, with a mean of 100 subjects. Gender was equally distributed in studies X, XVII and XXXIV. In studies XII, XIV, XVI, XXI, XXXI, XXXVI, XXXVIII and XXXIX subject groups consisted of more females than males, while in studies I, II, IV, V, VI, VIII, IX, XIII, XIX, XXII, XIV, XXVII, XXVIII, XXIX, XXX, XXXIII and XXXVII, the population consisted more of males. The population was 100% male in studies XXV, XXXII and XXXV. In studies III, VII, XI, XV, XVIII, XX, XXIII, XXVI the distribution between men and women was not stated.

The age range of the studied subjects was 16-82 years old. Studies XIII, XVI, XVII, XXI, XXV, XXVII, XXXII only reported subjects older than 30 years. Studies V, XXX, XXXVI and XXXVII had restricted age groups, which can represent bias of the inclusion criteria.

Subjects already referred to a dental faculty/practice were included in studies I, II, III, IV, VI, VII, VIII, IX, XV, XVI, XVIII, XIX, XX, XXI, XXII, XXIII, XXIV, XXVI, XXVII, XXVIII, XXXIII and XXIV. General representative populations were assessed from studies V, X, XI, XIII, XIV, XVII, XXIX, XXX, XXXI, XXXXVI and XXXVII. Specific populations were assessed in studies XII (Worker's Health Center Reference population), XXV (U.S. Veterans population), XXXII (Japanese manufacturing company employees), XXXV (Okadama Base of the Ground Self-Defense Force officials), XXXVIII (military personnel population) and XXXIX (dental population and employees of an Oslo industrial corporation).

Europe, Asia and South America were the most assessed regions in the studies, totalizing 28.2%, 20.5% and 28.2% of the studies, respectively.

The majority of the studies used visual and/or tactile clinical examination to detect NCCLs. Tooth wear index proposed by Smith and Knight (1984) was used as a way of assessment in studies II, III, V, X, XIII, XVI, XXIII and XXXV, and study XVII proposed a modified index based on Smith and Knight. Only study XXI assessed clinical signs on accurate diagnostic casts and thus, it was not included in the sub analysis.

Some studies related NCCL with dentin hypersensitivity and/or gingival recession in some degree. Studies VIII, IX, XIV, XV, XXII, XXIV and XXXIII associated NCCL with DH alone, and studies XII, XVI, XXV, XXIX, XXXI and XXXVIII associated NCCL with GR alone. Only studies VI and XXXIX related NCCL to both alterations. Study XXVIII found a negative association between NCCL and DH.

The risk factors assessed in each study are described in Table 3.

3.3. Risk of bias assessment

Quality assessment values, including methodology and statistical validity, are presented in the online appendix. Based on a summary of these criteria, the estimated potential risk of bias is low for nine studies, moderate for twelve, substantial for six and high for twelve studies.

3.4. Data analysis

The description of included studies is shown in Table 2 and the statistically significant differences found are described in Table 3. Meta-analysis was not possible to be conducted due to the heterogeneity of the studies. For more information on the analyzed data, see Online Appendix.

3.5. Grading

Table 4 shows a summary of the factors used to establish the body of evidence according to GRADE (2014) (88) and the risk of magnitude.

DISCUSSION

The main goal of this systematic review was to identify the risk factors which contributes to the formation and progression of NCCLs. The lack of standardization and heterogeneity of the included studies (online appendix S1 and S2) did not allow a meta-analysis. A major problem, already discussed in another systematic review (62) and also identified in this one, are the different diagnostic methods of NCCL assessment. While some studies adopted an already established tooth wear index (89), others would only use a binary dependent variable (presence or absence of NCCL) by simples visual examination in their data analysis. This fact makes the comparison between the studies more difficult.

Another problem is the different terms used to address NCCLs. As it is widely discussed in the literature, its etiology comprises the processes of attrition, abrasion, erosion/biocorrosion and abfraction (63). For a long time, these lesions were called by its main etiological factor like "abrasion lesions" (20,22,30) or "abfraction lesions" (14,27,31) or "erosion lesions" (30), as seen in this review. It also makes the comparison between studies difficult.

On the other hand, the separation between the risk factors is one limitation because all the processes can occur at the same time and NCCLs etiology has a really strong behavioral and lifestyle characteristic (63). Also, the majority of studies did not identify nor establish strategies to deal with cofounding factors, which can be any concomitant exposure or baseline characteristic (78) such as previous occlusal adjustment or orthodontic treatment, for example, which impact directly on the results. This might have influenced on the percentage of only 23% of studies with low risk of bias (1,4,5,11,14,38,42,53,81).

Age can be a determining factor on the etiology of NCCLs, as demonstrated in past studies (59,62,90) and in this review, with 39% of the studies considering it as a significant factor. It may be considered a low number, but it was one of the most cited factors on the studies included. As patients get older, more time teeth will be exposed to all the other relevant factors (62).

Occlusal aspects were the most relevant factors of the studies, being significant in 41% of them. Problem is that each study considers different aspects of occlusion such as "occlusal trauma", "occlusal wear" or "heavy occlusal forces" (14,23,33,35,84), interference on maximal intercuspal position (1), interference on non-working side (1,53), group function (8,15,26,32,84) and presence of wear facets (19,32,86,87), making the comparison between studies difficult. Also, the only randomized clinical trial included in this review (36) found no statistically significant difference in cervical wear rates between the adjusted and non-adjusted teeth, concluding that occlusal adjustment does not appear to halt the progression of NCCL. In contrast, Telles (86) found statistically significant correlation between previous presence of wear facets and the development of new lesions. Another 21% identified parafunctional habits as a risk factor, being bruxism (6–8,30,53,82) the most cited one. Kolak (9), in reverse, found significantly lower frequency of NCCLs among subjects who frequently chew gums. Hard objects biting hard was also considered a risk factor for NCCL (4).

This findings goes in accordance with a previous systematic review (91) which reported that the role of occlusion in the pathogenesis of NCCLs seems as yet undetermined because of the substantial amount of bias in the literature found, such as use of non-blinded examiners and no control of other etiological factors that might happen concomitantly. This is another limitation of cross-sectional studies, the most prevalent type of study included in this analysis. They are performed at only one assessing time, making it hard to isolate all the etiological factors and to determine exactly the causal factor.

Besides the difference in assessment methods, there is also the different statistical tests used in each study which can favor or disfavor some results, and some studies have not even made clear the statistic used (22,79,80,82). The most appropriate way of isolate each evaluated variable is by means of multivariate analysis, and the majority of studies in this review used univariate analysis or even chi-square tests, which compromises their quality and reliability. This can be seen on one study (9) where the frequency of toothbrushing was statistically different in the univariate analysis but not in the multivariate analysis.

In this regard, the influence of toothbrushing remains controversial. Some studies (1,2,20,30,31,35,92) found no significant difference between frequency of toothbrushing and NCCLs, while others did (5,6,8,14,52). Toothbrushing vigorousness and hardness of toothbrushes were also found to be relevant to NCCL (2,5,42,52,53), going in accordance with other studies which state that the high prevalence of lesions on the vestibular aspect automatically imply the influence of toothbrushing in NCCLs formation (93). However, according to some authors, toothbrushing is not capable of injuring enamel and dentin wear is minimal (48,94), and the fact that lesions can occur in one tooth without affecting the adjacent (95) or that NCCLs are present in non-brushing populations (96) leads to the conclusion that brushing habit acts as a catalyst in the process. Still, the evaluation method of the studies is not standardized as it mostly appears as questionnaires. Thus, new researches should be done in favor of this standardization so the role of toothbrushing gets clearer.

The role of acids in the progression of NCCL has been increasingly discussed. Likewise, as the other risk factors, the difficulty lies in the assessment methods, which again is not standardized. Smith (8) found significant association between NCCLs and citrus fruits, juices, alcohol, vinegar, soft drinks and more, while other studies (5,6,30,31,33,35) did not find any relation. These differences are probably due to the sample size and subjective characteristics of each population. Subjects can be act different even in the same population even. In one study (2), for example, the frequency of fresh fruit consumption was significantly associated with NCCL occurrence but consumption of fruit juice, carbonated beverages and vinegar were not. Two other studies (4,38) found an association between acid diet and age, demonstrating that older people who have acidic habits tends to be more likely to develop a NCCL than the middle-aged group. Only 8% of the studies showed significant association between intrinsic acids (salivary pH level, heartburn, gastric disease) and NCCL, despite the results seen previously where it is proven that prolonged exposure of gastric acids to the teeth leads to the dissolution of dental surface's specific components, causing loss of structure and also dentin hypersensitivity.

The association of gingival recessional and dentin hypersensitivity with NCCL is another important point of this review. It has been found a weak yet positive correlation between the presence of the three alterations (33), and the root exposure and dentinal tubules exposure might explain it (32,97). The correct management and treatment of each alteration will affect positively or not the progression of the associated NCCLs, so it is mandatory the knowledge regarding.

It is of great important to emphasize that the interaction between all the risk factors is unavoidable. Yet that should be a positive point as it is what exactly happens in reality, the studies' evaluation gets tricky, making it hard to come to an accurate conclusion about specific topics. This fact should guide new studies to come up with new strategies to deal with all the confounding factors that may be present, so that the quality of available literature increases.

CONCLUSION

This systematic review found factors in different categories to be associated with NCCLs such as age, frequency and vigorousness of toothbrushing, hardness of toothbrush, exposure to intrinsic and extrinsic acids, parafunctional habits and occlusal trauma. Despite the lack of standardization of methods of NCCL and risk factors assessment, its multifactorial etiology is clearly presented in this review.

REFERENCES

1. Yoshizaki KT, Francisconi-dos-Rios LF, Sobral MAP, Aranha ACC, Mendes FM, Scaramucci T. Clinical features and factors associated with non-carious cervical lesions and dentin hypersensitivity. J Oral Rehabil [Internet]. 2017;44(2):112–8. Available from: http://doi.wiley.com/10.1111/joor.12469
2. Yang J, Cai D, Wang F, He D, Ma L, Jin Y, et al. Non-carious cervical lesions (NCCLs) in a random sampling community population and the association of NCCLs with occlusive wear. J Oral Rehabil. 2016;43(12):960–6.
3. BOMFIM RA, CROSATO E, MAZZILLI LEN, FRIAS AC. Prevalence and risk factors of non-carious cervical lesions related to occupational exposure to acid mists. Braz Oral Res [Internet]. 2015;29(1):1–8. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-83242015000100280&lng=en&tlng=en
4. Lai ZY, Zhi QH, Zhou Y, Lin HC. Prevalence of Non-carious Cervical Lesions and Associated Risk Indicators in Middle-aged and Elderly Populations in Southern China. Chinese J Dent Res. 2015;18(1):41–50.
5. Que K, Guo B, Jia Z, Chen Z, Yang J, Gao P. A cross-sectional study: Non-carious cervical lesions, cervical dentine hypersensitivity and related risk factors. J Oral Rehabil. 2013;40(1):24–32.
6. Jiang H, Du MQ, Huang W, Peng B, Bian Z, Tai BJ. The prevalence of and risk factors for non-carious cervical lesions in adults in Hubei Province, China.

Community Dent Health [Internet]. 2011 Mar;28(1):22–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21485230

7. Tsiggos N, Tortopidis D, Hatzikyriakos A, Menexes G. Association between self-reported bruxism activity and occurrence of dental attrition, abfraction, and occlusal pits on natural teeth. J Prosthet Dent. 2008;100(1):41–6.

8. Smith WAJ, Marchan S, Rafeek RN. The prevalence and severity of non-carious cervical lesions in a group of patients attending a university hospital in Trinidad. J Oral Rehabil. 2008;35(2):128–34.

9. Kolak V, Pešić D, Melih I, Lalović M, Nikitović A, Jakovljević A. Epidemiological investigation of non-carious cervical lesions and possible etiological factors. J Clin Exp Dent. 2018;10(7):e648–56.

10. Hahn P, Reinhardt D, Schaller HG, Hellwig E. Root lesions in a group of 50-60 year-old Germans related to clinical and social factors. Clin Oral Investig. 1999;3(4):168–74.

11. Reyes E, Hildebolt C, Langenwalter E, Miley D. Abfractions and Attachment Loss in Teeth With Premature Contacts in Centric Relation: Clinical Observations. J Periodontol [Internet]. 2009;80(12):1955–62. Available from: http://www.joponline.org/doi/10.1902/jop.2009.090149

12. Ringelberg ML, Gilbert GH, Antonson DE, Dolan TA, Legler DW, Foerster U, et al. Root caries and root defects in urban and rural adults: the Florida Dental Care Study. J Am Dent Assoc [Internet]. 1996 Jul;127(7):885–91. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8754463

13. Akgül HM, Akgül N, Karaoglanoglu S, Ozdabak N. A survey of the correspondence between abrasions and tooth brushing habits in Erzurum, Turkey. Int Dent J [Internet]. 2003 Dec;53(6):491–5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14725378

14. Bernhardt O, Gesch D, Schwahn C, Mack F, Meyer G, John U, et al. Epidemiological evaluation of the multifactorial aetiology of abfractions. J Oral Rehabil [Internet]. 2006 Jan;33(1):17–25. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16409512

15. Brandini DA, de Sousa ALB, Trevisan CI, Pinelli LAP, do Couto Santos SC, Pedrini D, et al. Noncarious cervical lesions and their association with toothbrushing practices: in vivo evaluation. Oper Dent [Internet]. 2011;36(6):581–9. Available from:

http://www.ncbi.nlm.nih.gov/pubmed/21913861
16. Estafan A, Furnari PC, Goldstein G, Hittelman EL. In vivo correlation of noncarious cervical lesions and occlusal wear. J Prosthet Dent [Internet]. 2005 Mar;93(3):221–6. Available from: http://linkinghub.elsevier.com/retrieve/pii/S002239130400825X
17. Lussi A, Schaffner M, Hotz P, Suter P. Dental erosion in a population of Swiss adults. Community Dent Oral Epidemiol [Internet]. 1991 Oct;19(5):286–90. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1742995
18. 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. J Prosthet Dent [Internet]. 2007 Aug;98(2):150–8. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0022391307600481
19. Pegoraro LF, Scolaro JM, Conti PC, Telles D, Pegoraro TA. Noncarious cervical lesions in adults: prevalence and occlusal aspects. J Am Dent Assoc [Internet]. 2005 Dec;136(12):1694–700. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16383052
20. Radentz WH, Barnes GP, Cutright DE. A Survey of Factors Possibly Associated With Cervical Abrasion of Tooth Surfaces. J Periodontol [Internet]. 1976 Mar;47(3):148–54. Available from: http://doi.wiley.com/10.1902/jop.1976.47.3.148
21. Bergström J, Lavstedt S. An epidemiologic approach to toothbrushing and dental abrasion. Community Dent Oral Epidemiol [Internet]. 1979 Feb;7(1):57–64. Available from: http://www.ncbi.nlm.nih.gov/pubmed/282958
22. Sangnes G, Gjermo P. Prevalence of oral soft and hard tissue lesions related to mechanical toothcleansing procedures. Community Dent Oral Epidemiol [Internet]. 1976 Mar;4(2):77–83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1062255
23. Takehara J, Takano T, Akhter R, Morita M. Correlations of noncarious cervical lesions and occlusal factors determined by using pressure-detecting sheet. J Dent [Internet]. 2008 Oct;36(10):774–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18597913
24. Telles D, Pegoraro LF, Pereira JC. Incidence of noncarious cervical lesions and their relation to the presence of wear facets. J Esthet Restor Dent [Internet]. 2006;18(4):178–83; discussion 184. Available from:

http://www.ncbi.nlm.nih.gov/pubmed/16911416

25. Piotrowski BT, Gillette WB, Hancock EB. Examining the prevalence and characteristics of abfractionlike cervical lesions in a population of U.S. veterans. J Am Dent Assoc [Internet]. 2001;132(12):1694–701. Available from: http://dx.doi.org/10.14219/jada.archive.2001.0122

26. Antonelli JR, Hottel TL, Brandt R, Scarbecz M, Patel T. The role of occlusal loading in the pathogenesis of non-carious cervical lesions. Am J Dent. 2013;26(2):86–92.

27. Palomino-Gómez SP, Jeremias F, Finoti LS, Paredes-Coz G, Raveli DB. Influence of lateral excursion on vestibular cervical dental abfraction. Acta Odontol Latinoam [Internet]. 2011;24(3):283–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22550823

28. Pikdöken L, Akca E, Gürbüzer B, Aydil B, Taşdelen B. Cervical wear and occlusal wear from a periodontal perspective. J Oral Rehabil [Internet]. 2011 Feb;38(2):95–100. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20678102

29. Ahmed H, Durr-E-Sadaf, Rahman M. Factors associated with Non-Carious Cervical Lesions (NCCLs) in teeth. J Coll Physicians Surg Pak [Internet]. 2009 May;19(5):279–82. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19409158

30. Oginni AO, Olusile AO, Udoye CI. Non-carious cervical lesions in a Nigerian population: Abrasion or abfraction? Int Dent J. 2003;53(5):275–9.

31. Miller N, Penaud J, Ambrosini P, Bisson-Boutelliez C, Briançon S. Analysis of etiologic factors and periodontal conditions involved with 309 abfractions. J Clin Periodontol. 2003;30(9):828–32.

32. Aw TC, Lepe X, Johnson GH, Mancl L. Characteristics of noncarious cervical lesions: a clinical investigation. J Am Dent Assoc [Internet]. 2002 Jun;133(6):725–33. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12083648

33. Teixeira DNR, Zeola LF, Machado AC, Gomes RR, Souza PG, Mendes DC, et al. Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: A cross-sectional study. J Dent. 2018;76.

34. Sugita I, Nakashima S, Ikeda A, Burrow MF, Nikaido T, Kubo S, et al. A pilot

study to assess the morphology and progression of non-carious cervical lesions. J Dent [Internet]. 2017;57(2017):51–6. Available from: http://dx.doi.org/10.1016/j.jdent.2016.12.004

35. Sawlani K, Lawson NC, Burgess JO, Lemons JE, Kinderknecht KE, Givan DA, et al. Factors influencing the progression of noncarious cervical lesions: A 5-year prospective clinical evaluation. J Prosthet Dent [Internet]. 2016;115(5):571–7. Available from: http://dx.doi.org/10.1016/j.prosdent.2015.10.021

36. Wood ID, Kassir ASA, Brunton PA. Effect of Lateral Excursive Movements on the Progression of Abfraction Lesions. Oper Dent [Internet]. 2009;34(3):273–9. Available from: http://www.jopdentonline.org/doi/10.2341/08-100

37. Afolabi AO, Shaba OP, Adegbulugbe IC. Distribution and characteristics of non carious cervical lesions in an adult Nigerian population. Nig Q J Hosp Med [Internet]. 2012;22(1):1–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23175871

38. Afolabi AO, Shaba OP, Adegbulugbe IC. Clinical investigation of patient related factors in non carious cervical lesions. Nig Q J Hosp Med [Internet]. 2013;23(2):129–34. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24579510

39. Nieri M, Pini Prato GP, Giani M, Magnani N, Pagliaro U, Roberto R. Patient perceptions of buccal gingival recessions and requests for treatment. J Clin Periodontol. 2013;40(7):707–12.

40. Wada I, Shimada Y, Ikeda M, Sadr A, Nakashima S, Tagami J, et al. Clinical assessment of non carious cervical lesion using swept-source optical coherence tomography. J Biophotonics. 2015;8(10):846–54.

41. Mamaladze M, Khutsishvili L, Zarkua E. DISTRIBUTION OF CARIOUS AND NON-CARIOUS CERVICAL LESIONS AND GINGIVAL RECESSION AT AGE RELATED ASPECTS. Georgian Med News [Internet]. 2016 Jul;(256–257):18–23. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27661270

42. Haralur, Alqahtani, AlMazni, Alqahtani. Association of Non-Carious Cervical Lesions with Oral Hygiene Habits and Dynamic Occlusal Parameters. Diagnostics [Internet]. 2019 Apr 12;9(2):43. Available from: https://www.mdpi.com/2075-4418/9/2/43

43. Naik VK, Jacob CA, Nainar DA. Assessment of non-carious root surface defects in areas of gingival recession: A descriptive study. J Clin Exp Dent.

2016;18(4):397–402.
44. Young WG, Khan F. Sites of dental erosion are saliva dependent. J Oral Rehabil. 2002;29:35–43.
45. Khan F, Shahabi S. Dental cervical lesions associated with occlusal. Aust Dent J. 1999;(3):176–86.
46. Sadaf D, Ahmad Z. Role of brushing and occlusal forces in non-carious cervical lesions (NCCL). Int J Biomed Sci. 2014;10(4):265–8.
47. Addy M, Shellis RP. Interaction between Attrition,Abrasion and Erosion in Tooth Wear. Dent Eros [Internet]. 2006;20:17–31. Available from: https://www.karger.com/Article/FullText/93348
48. Shellis RP, Addy M. The Interactions between Attrition, Abrasion and Erosion in Tooth Wear. In 2014. p. 32–45. Available from: https://www.karger.com/Article/FullText/359936
49. Wiegand A, Schlueter N. The Role of Oral Hygiene: Does Toothbrushing Harm? In 2014. p. 215–9. Available from: https://www.karger.com/Article/FullText/360379
50. Robertson PB, Walsh MM, Greene JC. Oral effects of smokeless tobacco use by professional baseball players. Adv Dent Res [Internet]. 1997 Sep;11(3):307–12. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9524430
51. Kontaxopoulou I, Alam S. Risk Assessment for Tooth Wear. Prim Dent J [Internet]. 2015;4(3):25–9. Available from: http://openurl.ingenta.com/content/xref?genre=article&issn=2050-1684&volume=4&issue=3&spage=25
52. Bader JD, McClure F, Scurria MS, Shugars DA, Heymann HO. Case-control study of non-carious cervical lesions. Community Dent Oral Epidemiol [Internet]. 1996 Aug;24(4):286–91. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8871039
53. Alvarez-Arenal A, Alvarez-Menendez L, Gonzalez-Gonzalez I, Alvarez-Riesgo JA, Brizuela-Velasco A, DeLlanos-Lanchares H. Non-carious cervical lesions and risk factors: a case-control study. J Oral Rehabil [Internet]. 2018 Sep 25; Available from: http://www.ncbi.nlm.nih.gov/pubmed/30252966
54. Rahiotis C, Polychronopoulou A, Tsiklakis K, Kakaboura A. Cervical dentin hypersensitivity: A cross-sectional investigation in Athens, Greece. J Oral Rehabil. 2013;40(12):948–57.

55. Kopycka-Kedzierawski DT, Meyerowitz C, Litaker MS, Chonowski S, Heft MW, Gordan V V., et al. Management of Dentin Hypersensitivity by National Dental Practice-Based Research Network practitioners: Results from a questionnaire administered prior to initiation of a clinical study on this topic. BMC Oral Health [Internet]. 2017;17(1):1–7. Available from: http://dx.doi.org/10.1186/s12903-017-0334-0
56. Walls AWG, Silver PT, Steele JG. Impact of treatment provision on the epidemiological recording of root caries. Eur J Oral Sci. 2000;108(1):3–8.
57. da Silva AMBR, Valencise Magri L, da Silva MAMR, Sousa Neto MD de. Are the bite force and electromyographic activity altered in muscle TMD patients with abfraction lesions? Cranio - J Craniomandib Pract [Internet]. 2017;9634(November):1–7. Available from: http://doi.org/10.1080/08869634.2017.1407116
58. Kumar S, Kumar A, Debnath N, Kumar A, K. Badiyani B, Basak D, et al. Prevalence and risk factors for non-carious cervical lesions in children attending special needs schools in India. J Oral Sci [Internet]. 2015;57(1):37–43. Available from: https://www.jstage.jst.go.jp/article/josnusd/57/1/57_37/_article
59. Borcic J, Anic I, Urek MM, Ferreri S. The prevalence of non-carious cervical lesions in permanent dentition. J Oral Rehabil [Internet]. 2004;31(2):117–23. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15009594
60. Zuza A, Racic M, Ivkovic N, Krunic J, Stojanovic N, Bozovic D, et al. Prevalence of non-carious cervical lesions among the general population of the Republic of Srpska, Bosnia and Herzegovina. Int Dent J [Internet]. 2019 Feb 7;idj.12462. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/idj.12462
61. Sälzer S, Slot DE, Van der Weijden FA, Dörfer CE. Efficacy of inter-dental mechanical plaque control in managing gingivitis - a meta-review. J Clin Periodontol [Internet]. 2015 Apr;42:S92–105. Available from: http://doi.wiley.com/10.1111/jcpe.12363
62. Teixeira DNR, Thomas RZ, Soares PV, Cune MS, Gresnigt MMM, Slot DE. Prevalence of noncarious cervical lesions among adults: A systematic review. J Dent [Internet]. 2020 Apr;95:103285. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571220300191
63. Grippo JO, Simring M, Coleman TA. Abfraction, abrasion, biocorrosion, and the

enigma of noncarious cervical lesions: A 20-year perspective. J Esthet Restor Dent. 2012;24(1):10–23.
64. Grippo JO, Simring M, Schreiner S. Attrition, abrasion, corrosion and abfraction revisited: A new perspective on tooth surface lesions. J Am Dent Assoc [Internet]. 2004;135(8):1109–18. Available from: http://dx.doi.org/10.14219/jada.archive.2004.0369
65. Bartlett DW, Shah P. A Critical Review of Non-carious Cervical (Wear) Lesions and the Role of Abfraction, Erosion, and Abrasion. J Dent Res [Internet]. 2006 Apr 13;85(4):306–12. Available from: http://journals.sagepub.com/doi/10.1177/154405910608500405
66. Bartlett D. Etiology and prevention of acid erosion. Compend Contin Educ Dent [Internet]. 2009;30(9):616–20. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19998728
67. Barron RP, Carmichael RP, Marcon MA, Sàndor GKB. Dental erosion in gastroesophageal reflux disease. J Can Dent Assoc [Internet]. 2003 Feb;69(2):84–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12559056
68. Dawes C. What is the critical pH and why does a tooth dissolve in acid? J Can Dent Assoc [Internet]. 2003 Dec;69(11):722–4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14653937
69. Heasman PA, Holliday R, Bryant A, Preshaw PM. Evidence for the occurrence of gingival recession and non-carious cervical lesions as a consequence of traumatic toothbrushing. J Clin Periodontol. 2015;42(S16):S237–55.
70. Auad S, Moynihan P. Diet and dental erosion. Quintessence Int [Internet]. 2007 Feb;38(2):130–3. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17263152
71. Kitchens M, Owens B. Effect of Carbonated Beverages, Coffee, Sports and High Energy Drinks, and Bottled Water on the in vitro Erosion Characteristics of Dental Enamel. J Clin Pediatr Dent [Internet]. 2007 Apr 1;31(3):153–9. Available from: https://meridian.allenpress.com/jcpd/article/31/3/153/78456/Effect-of-Carbonated-Beverages-Coffee-Sports-and
72. Wongkhantee S, Patanapiradej V, Maneenut C, Tantbirojn D. Effect of acidic food and drinks on surface hardness of enamel, dentine, and tooth-coloured filling materials. J Dent [Internet]. 2006 Mar;34(3):214–20. Available from:

https://linkinghub.elsevier.com/retrieve/pii/S0300571205001223

73. Bartlett DW, Evans DF, Anggiansah A, Smith BG. A study of the association between gastro-oesophageal reflux and palatal dental erosion. Br Dent J [Internet]. 1996 Aug 24;181(4):125–31. Available from: http://www.nature.com/articles/4809187

74. Moazzez R, Bartlett D, Anggiansah A. Dental erosion, gastro-oesophageal reflux disease and saliva: how are they related? J Dent [Internet]. 2004 Aug;32(6):489–94. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571204000661

75. Rees JS. The biomechanics of abfraction. Proc Inst Mech Eng Part H J Eng Med [Internet]. 2006 Jan 17;220(1):69–80. Available from: http://journals.sagepub.com/doi/10.1243/095441105X69141

76. BORCIC J, ANIC I, SMOJVER I, CATIC A, MILETIC I, RIBARIC SP. 3D finite element model and cervical lesion formation in normal occlusion and in malocclusion. J Oral Rehabil [Internet]. 2005 Jul;32(7):504–10. Available from: http://doi.wiley.com/10.1111/j.1365-2842.2005.01455.x

77. Grippo JO. Noncarious cervical lesions: the decision to ignore or restore. J Esthet Dent [Internet]. 1992;4 Suppl:55–64. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1298328

78. Briggs Institute Joanna T. Joanna Briggs Institute Reviewer's Manual. Adelaide: The Joanna Briggs Institute; 2014.

79. Rusu Olaru A, Popescu MR, Dragomir LP, Rauten AM. Clinical Study on Abfraction Lesions in Occlusal Dysfunction. Curr Heal Sci J [Internet]. 45(4):390–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/32110441

80. Rusu Olaru A, Popescu MR, Dragomir LP, Popescu DM, Arsenie CC, Rauten AM. Identifying the Etiological Factors Involved in the Occurrence of Non-Carious Lesions. Curr Heal Sci J [Internet]. 45(2):227–34. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31624652

81. Teixeira DNR, Zeola LF, Machado AC, Gomes RR, Souza PG, Mendes DC, et al. Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: a cross-sectional study. J Dent [Internet]. 2018;(June):1–5. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571218301805%0Ahttp://www.ncbi.nlm.nih.gov/pubmed/29940290

82. Marinescu IR, Popescu SM, Răghici EC, Scrieciu M, Mercuț V, Turcu AA, et al. Etiological Aspects of Noncarious Dental Lesions. Curr Heal Sci J [Internet]. 43(1):54–61. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30595855
83. Antonelli JR, Hottel TL, Garcia-Godoy F. Abfraction lesions--where do they come from? A review of the literature. J Tenn Dent Assoc [Internet]. 2013;93(1):11–4. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=23909084%5Cnhttp://www.ncbi.nlm.nih.gov/pubmed/23909084
84. Brandini DA, Trevisan CL, Panzarini SR, Pedrini D. Clinical evaluation of the association between noncarious cervical lesions and occlusal forces. J Prosthet Dent [Internet]. 2012 Nov;108(5):298–303. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23107237
85. Hirata Y, Yamamoto T, Kawagoe T, Sasaguri K, Sato S. Relationship between occlusal contact pattern and non-carious cervical lesions among male adults. Int J Stomatol Occlusion Med [Internet]. 2010 Mar 23;3(1):10–4. Available from: http://link.springer.com/10.1007/s12548-010-0039-3
86. telles daniel, Pegoraro luiz fernando, Pereira jose carlos. Incidence of Noncarious Cervical Lesions and Their Relation to the Presence of Wear Facets. J Esthet Restor Dent [Internet]. 2006 Jul;18(4):178–83. Available from: http://doi.wiley.com/10.1111/j.1708-8240.2006.00015.x
87. TELLES D, PEGORARO LF, PEREIRA JC. Prevalence of Noncarious Cervical Lesions and Their Relation to Occlusal Aspects: A Clinical Study. J Esthet Restor Dent [Internet]. 2000 Jan;12(1):10–5. Available from: http://doi.wiley.com/10.1111/j.1708-8240.2000.tb00193.x
88. Guyatt GH, Oxman AD, Montori V, Vist G, Kunz R, Brozek J, et al. GRADE guidelines: 5. Rating the quality of evidence—publication bias. J Clin Epidemiol [Internet]. 2011 Dec;64(12):1277–82. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0895435611001818
89. Smith BG, Knight JK. An index for measuring the wear of teeth. Br Dent J [Internet]. 1984 Jun 23;156(12):435–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/6590081
90. Smith BG, Robb ND. The prevalence of toothwear in 1007 dental patients. J Oral Rehabil [Internet]. 1996 Apr;23(4):232–9. Available from:

http://www.ncbi.nlm.nih.gov/pubmed/8730269
91. SENNA P, DEL BEL CURY A, RÖSING C. Non-carious cervical lesions and occlusion: a systematic review of clinical studies. J Oral Rehabil [Internet]. 2012 Jun;39(6):450–62. Available from: http://doi.wiley.com/10.1111/j.1365-2842.2012.02290.x
92. Brandini DA, de Sousa ALB, Trevisan CI, Pinelli LAP, do Couto Santos SC, Pedrini D, et al. Noncarious cervical lesions and their association with toothbrushing practices: in vivo evaluation. Oper Dent [Internet]. 36(6):581–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21913861
93. Khan F, Young WG, Shahabi S, Daley TJ. Dental cervical lesions associated with occlusal erosion and attrition. Aust Dent J [Internet]. 1999 Sep;44(3):176–86. Available from: http://doi.wiley.com/10.1111/j.1834-7819.1999.tb00219.x
94. Azevedo AM de, Panzeri H, Prado CJ do, De-Mello JDB, Soares CJ, Fernandes-Neto AJ. Assessment in vitro of brushing on dental surface roughness alteration by laser interferometry. Braz Oral Res [Internet]. 2008 Mar;22(1):11–7. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-83242008000100003&lng=en&tlng=en
95. Litonjua LA, Andreana S, Bush PJ, Tobias TS, Cohen RE. Wedged cervical lesions produced by toothbrushing. Am J Dent [Internet]. 2004 Aug;17(4):237–40. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15478482
96. Faye B, Kane AW, Sarr M, Lo C, Ritter A V, Grippo JO. Noncarious cervical lesions among a non-toothbrushing population with Hansen's disease (leprosy): initial findings. Quintessence Int [Internet]. 2006 Sep;37(8):613–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16922020
97. Pashley DH. How can sensitive dentine become hypersensitive and can it be reversed? J Dent [Internet]. 2013 Jul;41:S49–55. Available from: https://linkinghub.elsevier.com/retrieve/pii/S030057121370006X
98. da Silva AMBR, Valencise Magri L, da Silva MAMR, Sousa Neto MD de. Are the bite force and electromyographic activity altered in muscle TMD patients with abfraction lesions? CRANIO® [Internet]. 2019 May 4;37(3):168–74. Available from: https://www.tandfonline.com/doi/full/10.1080/08869634.2017.1407116
99. Igarashi Y, Yoshida S, Kanazawa E. The prevalence and morphological types of non-carious cervical lesions (NCCL) in a contemporary sample of people.

Odontology. 2017;105(4):443–52.

100. Srisilapanan P, Jindarat M, Roseman J. The Prevalence and Severity of Tooth Wear in Type 2 Diabetic Patients. Int J Dent [Internet]. 2018 Dec 11;2018:1–5. Available from: https://www.hindawi.com/journals/ijd/2018/3608158/

Table 1. Search strategy and terms.

Search terms used for PubMed-MEDLINE and Cochrane Library. The search strategy was customized appropriately according to the database being searched considering differences in controlled vocabulary and syntax rules. The following strategy was used: ((Non carious cervical lesion*) OR (Non carious cervical lesions) OR (non carious cervical lesion AND etiological factors) OR (non carious cervical lesion AND risk factors) OR (Abfraction AND dental) NOT (neck) NOT (caries))

The asterisk (*) was used as a truncation symbol.

Table 2. Description of the included studies.

	N	%
Total of studies	39	100%
Geographical location		
Africa	2	5%
Asia	8	21%
Europe	11	28%
North America	7	18%
South America	11	28%
Type of participants		
General population	11	28%
Dental population (referred subjects)	22	57%
Specific population	6	15%
Age groups		
> 16 years old	28	72%
> 30 years old only	7	18%
Restricted age groups	4	10%
Assessment of NCCL		
Visual and tactile examination	29	74%
Smith and Knight index	8	21%
Modified Smith and Knight index	1	2.5%
Casts evaluation	1	2.5%
Associations with		
Dentin hypersensitivity	8	21%
Gingival recession	6	15%
Both	2	5%
Risk factors associated with NCCLs		
Age	19	48%
Oral hygiene/Toothbrushing	15	38%
Intrinsic acids	2	5%
Extrinsic acid	9	23%
Parafunctional habits	8	21%
Occlusal aspects	16	41%
Risk of bias		
High	12	31%
Substantial	6	15%
Moderate	12	31%
Low	9	23%

Table 3. Associations of NCCL with risk factors reported by included studies.

Study (ID)		**Toothbrushing**			**Acids**		**Occlusal aspects**					
	Age	Frequency of toothbrushing	Vigorousness/ power of toothbrushing	Hardness of toothbrush	Extrinsic	Intrinsic	Occlusal trauma/heavy occlusal forces/occlusal wear	Occlusion guidance	Premature contacts/ interferences	Wear facets	Parafunctional habits	TMD
Olaru et al., 2019 (I)												
Olaru et al., 2019 (II)												
Haralur et al., 2019 (III)				+				+				
Kolak et al., 2018 (IV)	+	+		+	+	+					+	
Alvarez-arenal et al., 2018 (V)	-		+		+	-		+	+		+	
Teixeira et al., 2018 (VI)	+		-		-	-			+		-	
da Silva et al., 2017 (VII)												-

Marinescu et al., 2017 (VIII)											+
Yoshizaki et al. 2017 (IX)	+	-		-	+				+		
Yang et al. 2016 (X)	+	-	+	-	+						-
Sawlani et al., 2015 (XI)		-	-	-	-	-	+	-	-	-	-
Bomfim et al. 2015 (XII)	+				+						
Lai et al. 2015 (XIII)	+				+	-					+
Que et al. 2013 (XIV)	+	+			-						-
Afolabi et al., 2013 (XV)	+				+						
Pikdoken, 2011 (XVI)	-						-				
Jiang et al., 2011 (XVII)	+	+			-						+

Palomino-Gomez, 2011 (XVIII)	+							-			
Reyes et al., 2009 (XIX)	-								-		
Wood et al., 2009 (XX)	+							-			
Tsiggos et al. 2008 (XXI)											+
Smith et al. 2008 (XXII)	+	+		+	+	+		+		+	+
Oginni, 2003 (XXIII)		-		-	-					+	
Miller, 2003 (XXIV)		-		-					+	+	
Piotrowski, 2001 (XXV)			-		-	-	-		+	-	+
Bader, 1996 (XXVI)		+	+		+	-			+		+
Antonelli, 2013 (XXVII)								+			

Aw, 2002 (XXVIII)	+									+	
Bernhardt et al., 2006 (XXIX)			+			-		-		+	-
Brandini et al., 2011 (XXX)	+		-	-	+						
Brandini et al., 2012 (XXXI)	+							+	+		
Hirata et al., 2010 (XXXII)	+	-							+		
Ommerborn et al., 2007 (XXXIII)								-	+		+
Pegoraro et al., 2005 (XXXIV)	-					-	-			+	-
Takehara et al., 2008 (XXXV)	+		-	+	-					+	-
Telles et al., 2006 (XXXVI)	+									+	
Telles et al., 2000 (XXXVII)	+									+	-

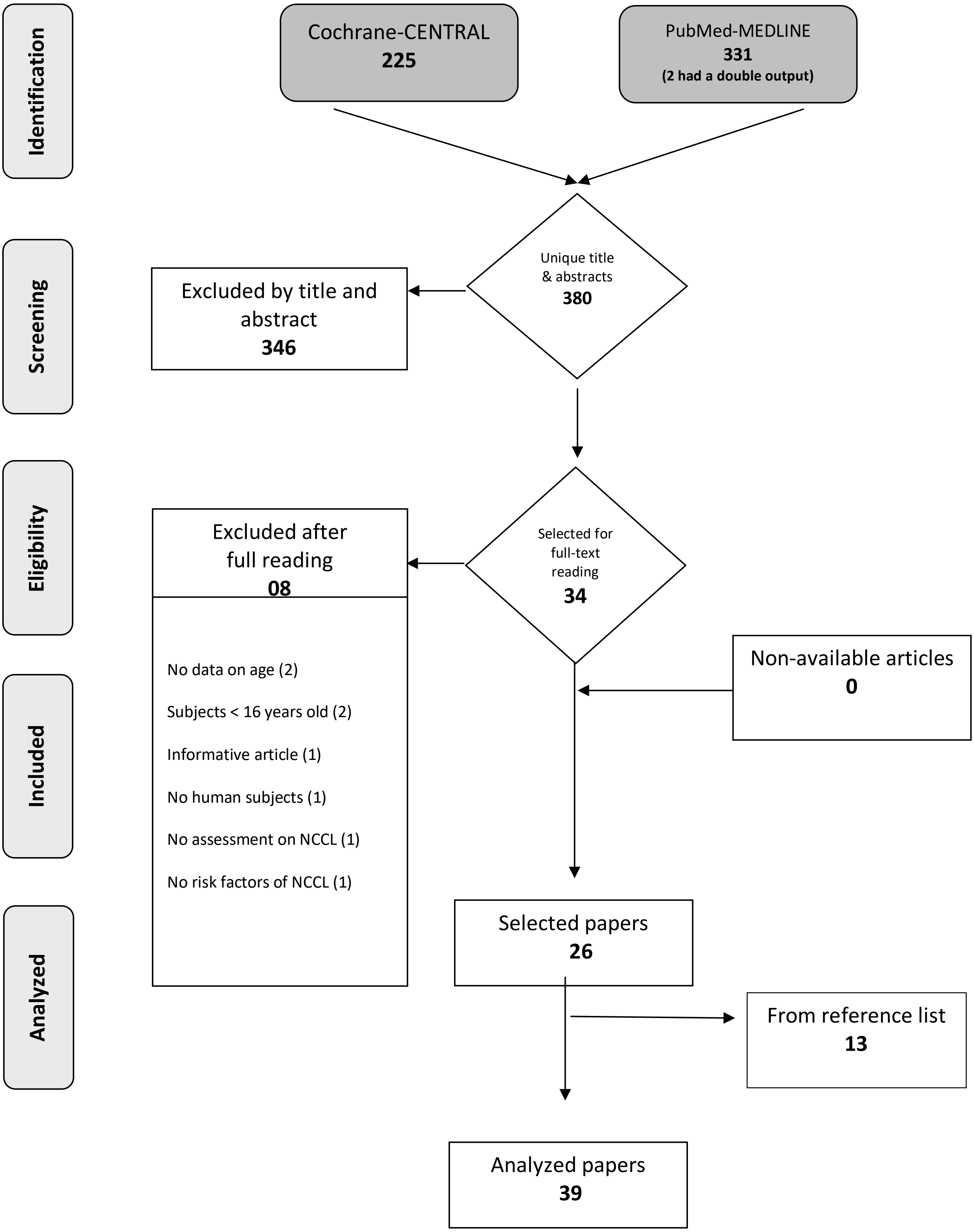
Radentz et al., 1976 (XXXVIII)	+	-		-
Sagnes and gjermo, 1976 (XXXIX)				

TMD, temporomandibular disorders
+, statistically significant positive correlation; -, no statistically significant correlation.
Blank cells are variables that were not statistically evaluated in the study.

Table 4. GRADE evidence profile.

Study design	Cross-sectional Randomized clinical trial Case-control Cohort
Risk of bias	Low to high
Consistency	Rather inconsistent
Precision	Rather precise
Directness	Rather generalizable
Publication bias	Possible
Body of evidence	Low to moderate
Magnitude of the finding	Moderate

Figure 1: Search and selection results



Online Appendix Information

Boxes, Figures & Tables

"Risk factors associated with noncarious cervical lesions: A Systematic Review"

Daniela N. R. Teixeira[1,2], MSD
Renske Z. Thomas[1], PhD
Paulo V. Soares[2], PhD
Marco S. Cune[1], PhD
Dagmar E. Slot[3], PhD
Marco M. M. Gresnigt[1,4], PhD

Authors' affiliations:

[1] University Medical Center Groningen, Department of Restorative Dentistry and Biomaterials, University of Groningen, Center for Dentistry and Oral Hygiene, Groningen, The Netherlands

[2] Federal University of Uberlândia, School of Dentistry, Uberlândia, Brazil

[3] Academic Centre for Dentistry Amsterdam (ACTA), University of Amsterdam and VU University, Amsterdam, The Netherland

[4] Martini Hospital, Department of specialized dentistry, Groningen, The Nehtherlands

Legends

Table S1. The details of the included studies.
Table S2. Risk factors assessed in the included studies.
Table S3. Excluded studies after full reading.
Table S4. Included studies from reference list.
Table S5. Studies included in the sub-analysis.
Table S6. Quality assessment of the selected cross-sectional studies.
Table S7. Quality assessment of the selected cohort study.
Table S8. Quality assessment of the selected randomized clinical trial.
Table S9. Quality assessment of the selected case-control study.
Table S10. Reporting guidelines of PRISMA.
Table S11. MOOSE Checklist.

Supporting Information Reference List. References for online supportive information

Table S1. The details of the included studies.

Authors, year (ID) **Study design**	**Subjects characteristics (n, type of population, country)**	**Age (mean ± SD, range), gender distribution**	**Clinical parameters used for NCCL diagnosis**	**Associations with GR and/or DH**
(79) **Olaru et al., 2019 (I)** Cross-sectional study	102 subjects Dental population Romania	20-80 years old ♂: 47 (46%) ♀: 55 (56%)	Visual and tactile examination: the depth of the lesions measured with a periodontal probe	n/a
(80) **Olaru et al., 2019 (II)** Cross-sectional study	21 subjects Dental population Romania	20-72 years old ♂: 10 (47.7%) ♀: 11 (52.3%)	Smith-Knight tooth wear index	n/a
(42) **Haralur et al., 2019 (III)** Cross-sectional study	100 subjects Dental population Saudi Arabia	>19 years old	Smith-Knight tooth wear index	n/a
(9) **Kolak et al., 2018 (IV)** Cross-sectional study	394 subjects Dental population Servia	27-75 years old ♂: 169 (43%) ♀: 225 (57%)	Visual and tactile examination with a dental mirror and a straight dental probe	n/a
(53) **Alvarez-Arenal et al., 2018 (V)** Cross-sectional study	280 subjects General population Spain	18-29 years old ♂: 106 (37.8%) ♀: 174 (62.2%)	Smith-Knight tooth wear index	n/a
(81) **Teixeira et al., 2018 (VI)** Cross-sectional study	185 subjects 5180 teeth Dental population	41.9 19-71 years old ♂♀ (0.68:1)	Visual and tactile examination with a dental mirror and a straight dental probe	61.9% of all lesions also presented hypersensitivity

	Brazil			25.7% of all lesions also presented gingival recession
(98) **da Silva et al., 2017 (VII)** Cross-sectional study	45 subjects Dental population Brazil	18-60 years old	Visual examination	n/a
(82) **Marinescu et al., 2017 (VIII)** Cross-sectional study	50 subjects Dental population Romania	18-56 years old ♂: 18 (36%) ♀: 32 (64%)	Visual examination	61% of the study group had also dentin hypersensitivity
(1) **Yoshizaki et al. 2017 (IX)** Cross-sectional study	118 subjects Dental population Brazil	≥18 years old ♂: 50 (42%) ♀: 68 (58%)	Visual and tactile analysis	50% of teeth that felt sensitivity with air had also NCCL; 74% of teeth that felt sensitivity with probe had also NCCL
(2) **Yang et al. 2016 (X)** Cross-sectional study	1320 subjects General population China	20-69 years old ♂: 660 (50%) ♀: 660 (50%)	Smith-Knight tooth wear index	n/a
(35) **Sawlani et al., 2015 (XI)** Cohort study	29 subjects General population USA	≥19 years old	Visual examination	n/a
(3) **Bomfim et al. 2015 (XII)** Cross-sectional study	100 subjects Specific population Brazil	44.15 ± 0.30 20-68 years old ♂: 55 (55%) ♀: 45 (45%)	Visual examination: Location in the cervical third of the tooth, no caries, wedge-shaped lesion with sharp edges, or C-shaped lesion with rounded edges	Tobacco influences gingival recession, thus contributing to NCCL (abrasivity theory)
(4) **Lai et al. 2015 (XIII)** Cross-sectional study	1759 subjects General population China	35-44 years old 65-74 years old ♂: 851 (48%) ♀: 908 (52%)	Smith-Knight tooth wear index	n/a

(5) **Que et al. 2013 (XIV)** Cross-sectional study	1023 subjects General population China	46.1 20-69 years old ♂: 1.06 ♀: 1 (ratio)	Visual and tactile analysis	86.6% of the patients with DH also had NCCL 63.8% of the sensitive teeth also had NCCL
(38) **Afolabi et al., 2013 (XV)** Cross-sectional study	34 subjects 356 teeth Dental population Lagos	51.2 ± 1.1 22-75 years old	Visual and tactile examination with periodontal probe	Dentin hypersensitivity was the predominant patient complaint and was age related
(28) **Pikdoken, 2011 (XVI)** Cross-sectional study	30 subjects Dental population Istambul	59.3 ± 8.89 yrs 45-80 years old ♂: 21 (70%) ♀: 9 (30%)	Smith-Knight tooth wear index	The depth of cervical wear tended to elevate as gingival recession increased
(6) **Jiang et al., 2011 (XVII)** Cross-sectional study	2160 subjects General population China	35-44 years old 65-74 years old ♂: 1080 (50%) ♀: 1080 (50%)	Modified Tooth wear index based on Smith and Knight	n/a
(27) **Palomino-Gomez, 2011 (XVIII)** Cross-sectional study	36 subjects Dental population Peru	40 ± 3-5 yrs 20-45 years old	Visual examination with probe	n/a
(11) **Reyes et al., 2009 (XIX)** Cross-sectional study	46 subjects Dental population USA	45 23-82 years old ♂: 14 (30%) ♀: 32 (70%)	Visual examination: abfraction-type lesions appearing as sharp, wedge-shaped loss of dental structure	n/a
(36) **Wood et al., 2009 (XX)** Randomized clinical trial	39 subjects Dental population United Kingdom	18-75 years old	Visual examination	n/a
(7) **Tsiggos et al. 2008 (XXI)** Cross-sectional study	102 subjects Dental population	44.1± 5.7 30-55 years old ♂: 54 (53%)	Visual examination: Clinical signs assessed on accurate diagnostic casts	n/a

	Greece	♀: 48 (47%)		
(8) **Smith et al. 2008 (XXII)** Cross-sectional study	156 subjects Dental population Trinidad and Tobago	40.6 16-73 years old ♂: 51 (33%) ♀: 105 (67%)	Visual examination: NCCL scored according to the dentine exposure and presence or abscence of symptoms	45% of all NCCLs were sensitive to compressed air
(30) **Oginni, 2003 (XXIII)** Cross-sectional study	106 subjects 1012 teeth Dental population Nigeria	47.09 ± 13.52 20-80 years old	Smith-Knight tooth wear index	n/a
(31) **Miller, 2003 (XXIV)** Cross-sectional study	61 subjects 309 teeth with NCCL Dental population France	48.8 22-81 years old ♂: 26 (42.6%) ♀: 35 (57.4%)	Visual examination	37.% of the lesions were juxta gingival; hypersensitivity of the lesions can be a complicating factor
(25) **Piotrowski, 2001 (XXV)** Cross-sectional study	32 subjects 103 teeth Specific population USA	60.4 38-80 years old ♂: 32 (100%)	Visual examination with periodontal probe	Control teeth had significantly less gingival recession than did affected teeth
(52) **Bader, 1996 (XXVI)** Case-control study	264 subjects Dental population USA	≥ 18 years old	Visual and tactile examination	n/a
(26)**Antonelli, 2013 (XXVII)** Cross-sectional study	20 subjects Dental population USA	51.6 35-66 years old ♂: 45% ♀: 55%	Visual and tactile examination	n/a
(32) **Aw, 2002 (XXVIII)** Cross-sectional study	57 subjects 171 teeth General population USA	21-80 years old ♂: 26 (46%) ♀: 31 (54%)	Visual and tactile examination	Sensitivity was most minimal or nonexistent

(14) **Bernhardt et al., 2006 (XXIX)** Cross-sectional study	2707 subjects General population Germany	40.6 ± 11.1 20-59 years old ♂: 1 ♀: 1.1 (ratio)	Visual and tactile examination: wedge-shaped had to be clearly discernable with a probe, even apically – carious, erosive or hollowed areas of hard substance loss were not counted as wedge shaped defects – the defects were recorded without gradation of lesion depth or width	25% of all teeth and 77% of teeth with abfractions showed recessions on the buccal aspect
(15) **Brandini et al., 2011 (XXX)** Cross-sectional study	58 subjects General population Brazil	23.6 ± 1.8 19-31 years old ♂: 15 (26%) ♀: 43 (74%)	Visual and tactile examination: losses of dental hard tissue near the CEJ without the development of caries were considered NCCL	n/a
(84) **Brandini et al., 2012 (XXXI)** Cross-sectional study	111 subjects General population Brazil	24.97 ± 4.71 19-38 years old ♂: 81 (73.6%) ♀: 30 (26.4%)	Visual and tactile examination: losses of dental hard tissue near the CEJ without the development of caries were considered NCCL	A significant association was found between the presence of NCCL and gingival recession
(85) **Hirata et al., 2010 (XXXII)** Cross-sectional study	386 subjects Specific population Japan	30-58 years old ♀: 386 (100%)	Visual and tactile examination: Cervical lesions that did not have softened dentin and that showed a spheroid or wedge-shaped loss of dentin and/or enamel	n/a
(18) **Ommerborn et al., 2007 (XXXIII)** Cross-sectional study	91 subjects Dental population Germany	28.37 ± 4.89 20-39 years old ♂: 33 (36%) ♀: 58 (64%)	Visual examination: lesions localized in the cervical third of a tooth, free of caries, wedge-shaped, with sharp edges	55.6% of all the subjects with one NCCL or more also stated having one tooth or more with hypersensitivity
(19) **Pegoraro et al., 2005 (XXXIV)** Cross-sectional study	70 subjects Dental population Brazil	25-45 years old ♂: 35 (50%) ♀: 35 (50%)	Visual and tactile examination: tip of the probe perpendicular to the surface – if the probe was retained by some irregularity it was considered a NCCL	n/a
(23) **Takehara et al., 2008 (XXXV)** Cross-sectional study	159 subjects Specific population Japan	36.2 ± 12.3 20-50+ years old ♀: 159 (100%)	Smith-Knight tooth wear index	n/a
(24) **Telles et al., 2006 (XXXVI)** Cross-sectional study	40 subjects General population	16-22 years old ♂: 22 (55%) ♀: 18 (45%)	Visual and tactile examination: if an irregularity was felt, it was considered an NCCL even if it was localized at the cementoenamel junction	n/a

	Brazil			
(87) **Telles et al., 2000 (XXXVII)** Cross-sectional study	48 subjects General population Brazil	16-24 years old ♂: 20 (41.7%) ♀: 28 (58.3%)	Visual and tactile examination: if an irregularity was felt, it was considered an NCCL even if it was localized at the cementoenamel junction	n/a
(20) **Radentz et al., 1976 (XXXVIII)** Cross-sectional study	80 subjects Specific population USA	24.0 17-45 years old ♂: 66 (82%) ♀: 14 (18%)	Visual and tactile examination: any area with any explained tooth loss regardless of suspected causes	Cervical abrasion is related to gingival recession
(22) **Sagnes and Gjermo, 1976 (XXXIX)** Cross-sectional study	261 subjects Specific population Norway	18-50+ years old ♂: 61% ♀: 39%	Visual and tactile examination: V-shaped grooves in the gingival area of the vestibular and lingual surfaces of the teeth were described as small or large according to a depth of less or more than 1 mm	The areas most frequently affected by gingival lesions also seemed to exhibit the highest prevalence of hard tissue lesion; hypersensitivity on probing was recorded in 23% of the abrasional lesions

Abbreviations:
NCCL – noncarious cervical lesions; N/A – not applicable; GR – gingival recession; DH – dentin hypersensitivity.

Table S2. Risk factors assessed in the included studies (other than demographics).

Study	General characteristics	Oral hygiene/Brushing	Acid diet	Gastric diseases	Para-functional habits	Occlusal aspects	Statistical test/Significant associations	General conclusions
I	Age Gender	Frequency of toothbrushing, time allocated to dental brushing, type of toothbrush, type of toothpaste, brushing technique	-	-	Nocturnal bruxism	-	No statistics	Age, gender, bruxism, use of hard toothbrushes associated with improper brushing techniques were relevant for the occurrence of NCCL
II	Age Gender Type of occupation Swimming activities Drug use	Frequency of toothbrushing, brushing technique, use of toothpicks	Fruits, fruit juices, carbonated drinks, consumption of seeds	Gastro-esophageal reflux	Nail biting Nighttime bruxism Objects between dental arches	-	No statistics	Higher wear degree on male gender; 71% of participants on acid diet
III	Age Gender	Brushing frequency, brushing duration, brushing technique, tooth brush	Consumption of citric drinks	-	-	Occlusion time, right disocclusion time, left disocclusion time, protrusive disocclusion time Occlusal contacts were confirmed with shim stock	Binary logistic regression/Yes	The use of a hard toothbrush and horizontal brushing technique were more frequent, the mean occlusion time was longer, and left and lateral disocclusion time were significantly associated with NCCL
IV	Age Gender	Brushing frequency, type of toothbrush,	Consumption of citrus fruits and	-	Nail biting Bruxism Chewing gun	-	Univariate logistic regression/Yes	Age, frequent consumption of citrus fruit and lower salivary

	Place of residence Occupation Drug use	brushing technique	fruit drinks, carbonated and energy drinks Saliva analysis					pH value were associated with an increased occurrence of NCCLs, while chewing gums habit was associated with a decreased occurrence of NCCLs
V	Age Gender	Way of brushing (vigorous)	Consumption of soft drinks, acidic or citrus fruits, salads seasoned with vinegar or lemon/day, extrinsic acids	Vomiting or gastro-esophageal reflux	Bruxism Attrition	Protrusive interferences, right and left laterality interferences on working and non-working sides	Uni and multivariate logistic regression/Yes	The risk factors that explain the presence of NCCLs in the predictive model are: self-reported bruxism, attrition, the consumption of salads seasoned with vinegar, vigorous brushing and periodontal index. Protrusive interferences and interference on the non-working side are only significant in the univariate analysis
VI	Age Gender	Brushing with excessive force	Consumption of acid food and drinks	Any type of gastric disease	Any type of parafunctional habit	Patients' premature contacts were identified in centric relation, in all movements	Multivariate logistic regression/Yes	Age, gender and occlusal trauma were relevant factors for NCCL
VII	Age	-	-	-	Bite force Temporomandibular disorders (myofascial pain)	-	ANOVA One Way/No	Temporomandibular disorder patients with and without afraction lesions exhibited similar results in the analysis of bite force and electromyographic without differences

VIII	Age Gender	Brushing method	Eating behavior	-	Bruxism	-	No statistics	The factors associated with NCCL were gender (male), method of toothbrushing, presence of erosive food and bruxism
IX	Age Tooth type Arch type	-	Consumption of wine and alcoholic beverages Consumption of acidic fruit juices	-	-	Premature contacts were identified in maximum intercuspidatio n and on the non-working side	Multilevel Poisson regression analyses/Yes	The factors associated with NCCL were age, presence of premature contacts in maximum intercuspidation and on the non-working side, and frequent consumption of wine and alcoholic beverages
X	Age	Power of toothbrushing	Frequency of eating fresh fruits	-	Occlusive wear	-	Bivariate correlation analysis/Yes	The factors associated with NCCL were age, heavy power of toothbrushing, eating fresh fruits at least one time per day, and the interaction effect of both power of toothbrushing and higher frequencies of eating fresh fruits
XI	Medical condition	Frequency of toothbrushing, type of toothbrush, force on toothbrushing, brushing technique	Diet	Gastric reflux, dry mouth, hyposalivati on	Presence of wear facets (grind teeth/nails bite)	Occlusal forces Group function	Mixed model analysis/Yes	Heavy occlusal forces play a significant role in the progression of NCCLs
XII	Age Smoking habit	-	Exposure to acid mists	-	-	-	Unconditional logistic regression/Yes	The factors associated with NCCL were age, exposure to acid mists and smoking habit
XIII	Age	Frequency of brushing, use of	Frequency of consumption	Recurrence of gastric	Hard objects biting, bruxism,	-	Bivariate analysis	The factors associated with NCCL were age,

		toothpicks, method of brushing, use of dental floss	of acid fruits, carbohydrate beverages, vinegar beverages	acid conditions	chewing on one side		(ANCOVA)/Yes	suburban areas lifestyle, frequent use of toothpicks, hard objects biting and vinegar beverages once a week
XIV	Age Gender	Frequency of toothbrushing, method of tooth-brushing, duration of a toothbrush used, intensity of toothbrushing, stiffness of toothbrush, toothbrushing after eating	Frequency of consuming fresh fruits and juices, frequency of having carbonated beverage	Gastroesophageal reflux disease	Bruxism	-	Binary logistic regression/Yes	The factors associated with NCCL were toothbrushing horizontally, frequency of toothbrushing, use of toothbrush for longer time
XV	Age Extensiveness, severity and distribution of NCCL	Toothbrushing technique	Dietary habits	-	-	-	Chi-square test/Yes	The factors associated with NCCL were dietary habits and age; extensiveness of the lesions and age; gender and extensiveness; toothbrushing technique and extensiveness and distribution of the lesions
XVI	Age Gingival recession Tooth mobility	Plaque accumulation Pocket depth	-	Present or past history of gastroesophageal reflux disease, heartburn, frequent vomiting, xerostomia	Bruxism or any other parafuncional habit	Occlusal wear	2-level mixed model analysis/Yes	The rate of gingival recession leading to denudation of root surface seems to be a predisposing factor for NCCL; possible combined effects of abrasion, erosion and abfraction

XVII	Age Location Family income Ethnic Education	Frequency of toothbrushing	Consumption of soft drinks and fruit juices	-	Bruxism, unilateral mastication	-	Multiple logistic regression/Yes	Age, location, frequency of toothbrushing, bruxism and family income were all factors related to NCCL
XVIII	Age	-	-	-	Inclusion criteria: no bruxism	Evaluation of lateral canine guidance and group function	Chi-square test/Yes	Age is moderately correlated to abfraction; no statistical differences were found regarding the number of abfraction teeth and type of excursive movements
XIX	Age Clinical attachment loss	-	-	-	-	Premature contacts in centric relation (PCCR)	Wilcoxon signed rank test/No	Associations between PCCR and NCCL were not demonstrated
XX	Age Attachment loss Gingival bleeding Mobility of teeth	-	-	-	-	Presence of lateral excursive movements	Paired-samples t-test/No	Occlusal adjustment does not appear to halt the progression of NCCL
XXI	Age	-	-	-	Self-reported bruxism	-	Chi-square test/Yes	A significant association between the self-reported status of bruxism and the occurrence of NCCL was found
XXII	Age Gender Habit of swimming	Frequency of toothbrushing, type of toothbrush	Vegetarian food, presence of citrus fruits, soft drinks, alcohl, yogurt, chewing gum and	Heartburn, gastric reflux and headaches	Bruxism, clicking TPM joint, broken fillings, faceting	Group function	Odds ratio/Yes	The factors associated with NCCL were: dietary factors (vegetarians, presence of citrus fruits, soft drinks, alcohrel, yogurt, chewing gum and effervescent vitamin C), medical conditions (heartburn, gastric reflux

			effervescent vitamin C					and headaches), occlusal factors (bruxism, clicking TPM joint, broken fillings, group function, faceting), toothbrushing twice a day, use of hard or medium toothbrush and habit of swimming
XXIII	-	Mode of oral hygiene, toothbrushing technique, frequency of toothbrushing, type of toothbrush, handedness of patient	Consumption of acid food	-	-	Occlusal wear, severity of tooth wear	Fisher Exact test/No	Most cervical lesions are not the result of abfraction alone but rather the result of an interplay of multiple factors including abrasion and erosion. However, wedge-shaped lesions seems to be primarily due to occlusal forces
XXIV	Age Edges and apical limits of NCCL	Presence of plaque or calculus, gingival abrasion or periodontitis	-	-	Bruxism, tongue thrusting	Wear facets, canine disclusion, group function, balancing interference, edge bite, open bite, cross bite, prognathism, rotation	No statistics	The presence of wear facets and group function are highly associated with abfractions; there is no evidence of toothbrushing as an etiological factor for abfraction formation
XXV	Age	Presence of plaque, toothbrushing technique, handedness of the patient, other oral hygiene's habits	Diet evaluation	-	Bruxism	Wear facets, evidence of prematurity in' centric occlusion, interference in balancing, working or protrusive	Chi-square test/No	Most of the NCCLs had the clinical appearance and features commonly associated with facial toothbrush abrasion or chemical erosion. It does seem clear that most cervical lesions are not

						excursive movements on all affected and control teeth		the result of abfraction alone
XXVI	Age Gender Saliva Use of medications	Oral hygiene behavior: frequency of toothbrushing, brushing technique, use of mouthwash, dental floss, handedness of the patient	Frequency of acid food	Endogenous acid: history of ulcera, hiatal hernia, vomiting, heartburn, stomachache	Bruxism, chewing habit, clenching, maxillary/mandibular torus	Lateral excursive movements	Bivariate logistic regression analyses/Yes	Multiple causal mechanisms may operate in the initiation and progression of individual lesions
XXVII	Age	-	-	-	-	Occlusal contacts in maximum intercuspal position and during working, balancing and protrusive excursions	Chi-square test/Yes	The number of NCCL observed in teeth contacting during group function is significantly higher than canines in canine guided occlusion
XXVIII	Age Gender Tooth mobility	-	-	-	-	Angle's classification, guidance in excursion, wear facets	Logistic regression analysis/Not clear	Most NCCL were present in older patients with group function excursive guidance, with a preponderance of wear facets and little or no mobility
XXIX	Age Gender Presence of restorations	Frequency of toothbrushing	Intake of frui juices	-	Bruxism	Occlusal wear; tooth contacts in centric relation and	Multivariable analysis/Yes	Abfractions are associated with gingival recession, occlusal wear, inlay restorations, altered tooth

	Recession of the gingiva					excursive movements		position and tooth brushing frequency
XXX	Age Gender	Frequency of toothbrushing, toothbrush firmness, type of toothpaste, force applied during toothbrushing	-	-	-	-	Chi-square test; Fisher exact test; t-test/Yes	Toothbrush firmness (medium and hard) was the only variable that was statistically significantly associated with the presence of NCCLs
XXXI	Age Gender Presence of gingival recession Dental/restoration fracture Fracture line	-	-	-	-	Tooth wear; evaluation of type guide to lateral movement and presence of occlusal interference	Chi-square test; Fisher exact test; t-test/Yes	A significant association was found between the presence of NCCL and age, gingival recession, occlusal trauma, presence and location of tooth wear and group function as lateral guidance
XXXII	Age	Frequency of toothbrushing	-	-	Bruxism	Malocclusion; temporomandibular disorders; evaluation of lateral movements	Logistic regression analysis/	Bilateral mediotrusive-side contact and laterotrusive-side contact in incisor-canine-premolar areas were significantly associated with the presence of NCCLs
XXXIII	Age Gender Education Tooth sensitivity	-	-	-	Bruxism	Occlusal restorations; type of lateral guidance	Chi-square; Mann-Whitney U test/Yes	Bruxism subjects demonstrated significantly more NCCLs and tooth sensitivity than the control group; type of occlusion guidance scheme seems to be of minor importance
XXXIV	Age Gender Medical history	0	Acidic beverages	Any regurgitation problem	Tooth clenching, grinding, tongue biting, lip biting,	Wear facets; occlusal contacts in maximal	Chi-square; Mann-Whitney; t-test/Yes	There is a significant correlation between the prevalence of NCCLs and

	Medication intake Stress experience				gum chewing, cheek biting, biting objects or nail biting; chew unilaterally	intercuspal position and during lateral and protrusive movements; orthodontic treatment		the presence of occlusal wear facets
XXXV	Age Handedness	Frequency of toothbrushing, hardness of bristles, toothbrushing technique and toothbrushing pressure; use of dentifrice and type of tooth-cleaning device other than a toothbrush	-	-	Bruxism	Occlusal force, occlusal contact area, occlusal pressure in maximal intercuspal position	Uni and multivariate logistic analysis/Yes	Multivariate logistic analysis revealed that age, toothbrushing pressure and occlusal contact area are associated with NCCL
XXXVI	Age	-	-	-	-	Wear facets	Chi-square test/Yes	There is a statistically significant correlation between the presence of NCCL and wear facets
XXXVII	Age Stress experience	-	-	-	Clenching or grinding teeth, biting cheeks, tongue or nails (frequency); chew unilaterally	Orthodontic treatment; wear facets	Chi-square test/Yes	There is a significant correlation between the prevalence of NCCLs and the presence of wear facets; age is a significant factor
XXXVIII	Age Gender Race Handedness Gingival recession	Plaque; gingival bleeding; quantity of dentifrice used, bristle stiffness of toothbrush, toothbrushing	-	-	-	-	Chi-square test; student t-test/Yes	Age, gingival recession, plaque, gingival bleeding and quantity of dentifrice used are associated with cervical abrasions

		technique, toothbrushing frequency, sequence of toothbrushing						
XXXIX	Age Gender Gingival retraction	Presence of plaque, toothbrushing technique and frequency	-	-	-	-	No statistics	The subjects with a good oral hygiene status, as well as those who brushed more than twice daily, showed a high frequency of hard and soft tissue lesions

Table S3. Excluded studies after full reading.

Exclusion criteria	Study
Assessment in extracted teeth	Igarashi et al., 2017 (99)
Age of the subjects was not provided	Khan and Shahabi, 1999 (45) Sadaf and Ahmad, 2014 (46)
Age of the subjects did not match inclusion criteria	Kumar et al., 2015 (58) Zuza et al., 2019 (60)
Informative article	Kontaxopoulou and Alam, 2015 (51)
No assessment of NCCL	Srisilapanan et al., 2018 (100)
No risk factors on NCCL	Afolabi et al., 2012 (37)
Number of excluded papers in total	08

Table S4. Included studies from reference list.

Included studies from reference list of the first 26 selected papers
1. Antonelli, 2013 (26) 2. Aw, 2002 (32) 3. Bernhardt, 2006 (14) 4. Brandini, 2011 (15) 5. Brandini, 2012 (84) 6. Hirata, 2010 (85) 7. Ommerborn, 2007 (18) 8. Pegoraro, 2005 (19) 9. Takehara, 2008 (23) 10. Telles, 2006 (24) 11. Telles, 2000 (87) 12. Radentz, 1976 (20) 13. Sangnes, 1976 (22)

Table S5. Studies included in the sub analysis.

Sub analysis	Groups	Studies included
Age	Only 30+ subjects(25)	Lai, 2015 Pikdoken, 2011 Jiang, 2011 Tsiggos, 2008 Piotrowski, 2001 Antonelli, 2013 Hirata, 2010
	> 16 years old	Olaru et al., 2019 Olaru et al., 2019 Haralur et al., 2019 Kolak, 2018 Teixeira et al., 2018 da Silva et al., 2017 Marinescu et al., 2017 Yoshizaki, 2017 Yang, 2016 Sawlani et al., 2015

		Bomfim, 2015 Que, 2013 Afolabi, 2013 Palamino-Gomez, 2011 Reyes, 2009 Wood, 2008 Smith, 2008 Oginni, 2003 Miller, 2003 Bader, 1996 Aw, 2002 Bernardt, 2006 Brandini, 2012 Ommerborn et al., 2007 Pegoraro et al., 2005 Takehara et al., 2008 Radentz et al., 1976 Sangnes & Gjermo, 1976
Population	General population	Alvarez-Arenal, 2018 Yang, 2016 Sawlani, 2015 Lai, 2015 Que, 2013 Jiang, 2011 Bernardt, 2006 Brandini, 2011 Brandini, 2012 Telles, 2006 Telles, 2000
	Dental population (referred to a dental practice)	Olaru, 2019 Olaru, 2019 Haralur, 2019 Kolak, 2018 Teixeira, 2018 da Silva, 2017 Marinescu, 2017 Yoshizaki, 2017 Afolabi, 2013 Pikdoken, 2011 Palamino-Gomez, 2011 Reyes, 2009 Wood, 2008 Tsiggos, 2008 Smith, 2008 Oginni, 2003 Miller, 2003 Bader, 1996 Antonelli, 2013 Aw, 2002 Ommerborn, 2007 Pegoraro, 2005
	Specific population	Bomfim, 2015 Piotrowski, 2001 Hirata, 2010 Takehara, 2008 Radentz, 1976 Sangnes e Gjermo, 1976
	Europe	Olaru, 2019 Olaru, 2019 Kolak, 2018

		Alvarez-Arenal, 2018 Marinescu, 2017 Wood, 2009 Tsiggos, 2008 Miller, 2003 Bernhardt, 2006 Ommerborn, 2007 Sangnes e Gjermo, 1976
	Asia	Haralur, 2019 Yang, 2016 Lai, 2015 Que, 2013 Pikdoken, 2011 Jiang, 2011 Hirata, 2010 Takehara, 2008
Geographical location	South America	Teixeira, 2018 da Silva, 2017 Yoshizaki, 2017 Bomfim, 2015 Palamino-Gomez, 2011 Smith, 2008 Brandini, 2011 Brandini, 2012 Pegoraro, 2005 Telles, 2006 Telles, 2000
	North America	Sawlani, 2015 Reyes, 2009 Piotrowski, 2001 Bader, 1996 Antonelli, 2013 Aw, 2002 Radentz, 1976
	Africa	Afolabi, 2013 Oginni, 2003
Diagnosis	Visual and/or tactile examination	Olaru, 2019 Kolak, 2018 Teixeira, 3018 da Silva, 2017 Marinescu, 2017 Yoshizaki, 2017 Sawlani, 2015 Bomfim, 2015 Que, 2013 Afolabi, 2013 Palamino-Gomez, 2011 Reyes, 2009 Wood, 2009 Smith, 2008 Miller, 2003 Piotrowski, 2001 Bader, 1996 Antonelli, 2013 Aw, 2002 Bernardt, 2006 Brandini, 2011 Brandini, 2012 Hirata, 2010

		Ommerborn, 2007 Pegoraro, 2005 Telles, 2006 Telles, 2000 Radentz, 1976 Sangnes & Gjermo, 1976
	Smith and Knight index	Olaru, 2019 Haralur, 2019 Alvarez-Arenal, 2018 Yang, 2016 Lai, 2015 Pikdoken, 2011 Oginni, 2003 Takehara, 2008
	Modified index based on Smith and Knight	Jiang, 1011
	Casts evaluation	Tsiggos, 2008
Association with dentin hypersensitivity and/or gingival recession	Dentin hypersensitivity	Marinescu, 2017 Yoshizaki, 2017 Que, 2013 Afolabi, 2013 Smith, 2008 Miller, 2003 Ommerborn, 2007
	Gingival recession	Bomfim, 2015 Pikdoken 2011 Piotrowski, 2001 Bernhardt, 2006 Brandini, 2012 Radentz, 1976
	Dentin hypersensitivity and gingival recession	Teixeira, 2018 Sagnes e Gjermo, 1976
Risk factors significantly associated with NCCL	**General characteristics**	
	Age	Kolak, 2018 Teixeira, 2018 Yoshizaki, 2017 Yang, 2016 Bomfim, 2015 Lai, 2015 Que, 2013 Afolabi, 2013 Jiang, 2011 Palamino-Gomez, 2011 Wood, 2009 Smith, 2008 Aw, 2002 Brandini, 2011 Brandini, 2012 Takehara, 2008 Telles, 2006 Telles, 2000 Radentz, 1976
	Gender	Teixeira 2018 Marinescu, 2017 Afolabi, 2013

	Smoking habit	Bomfim, 2015
	Suburban area lifestyle	Lai, 2015
	Family income	Jiang, 2011
	Swimming habit	Smith, 2008
	Oral hygiene/Toothbrushing	
	Frequency of toothbrushing	Que, 2013 Jiang, 2011 Smith, 2008 Bader, 1996 Bernhardt, 2006 Sangnes e Gjermo, 1976
	Vigorous brushing/power of toothbrushing	Alvarez-Arenal, 2018 Yoshizaki, 2017 Yang, 2016 Takehara, 2008
	Tootothbrushing method/technique	Marinescu, 2017 Que, 2013
	Hardeness of toothbrush	Smith, 2008 Bader, 1996 Brandini, 2011
	Use of toothpicks	Lai, 2015
	Quantity of dentifrice	Radentz, 1976
	Periodontal index	Alvarez-Arenal, 2018 Radentz, 1976
	Extrinsic acids	
	Frequent consumption of citrus fruit	Kolak, 2018 Yang, 2016
	Consumption of salads seasoned with vinegar/vinegar beverages	Alvarez-Arenal, 2018 Lai, 2015
	Acid diet in general	Marinescu, 2017 Afolabi, 2013 Smith, 2008
	Consumption of wine and alcoholic beverages	Yoshizaki, 2017
	Exposure to acid mists	Bomfim, 2015
	Intrinsic acids	
	Salivary pH level	Kolak, 2018
	Heartburn, gastric disease	Smith, 2008
	Parafunctional habits	

	Bruxism	Alvarez-Arenal, 2018 Marinescu, 2017 Jiang, 2011 Tsiggos, 2008 Smith, 2008 Oginni, 2003
	Chewing gun	Kolak, 2018
	Hard objects biting	Lai, 2015
	Occlusal aspects	
	Occlusal trauma/heavy occlusal forces/occlusal wear	Teixeira 2018 Sawlani, 2015 Bernhardt, 2006 Brandini, 2012
	Left disocclusion time Lateral disocclusion time	Haralur, 2019
	Interference on maximal intercuspal position	Yoshizaki, 2017
	Protrusive interference	Hirata, 2010
	Interference in non-working side	Alvarez-Arenal, 2018 Yoshizaki, 2017
	Group function	Antonelli, 2013 Aw, 2002 Brandini, 2011 Brandini, 2012 Takehara, 2008 Smith, 2008
	Clicking temporomandibular joint	Smith, 2008
	Presence of wear facets	Smith, 2008 Aw, 2002 Pegoraro, 2005 Telles, 2006 Telles, 2000
	Altered tooth position	Bernhardt, 2006

Table S6. Quality assessment of the selected cross-sectional studies.

STUDY (selection ID)	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XII*	*XIII*	*XIV*	*XV*	*XVI*	*XVII*	*XVIII*	*XIX*	*XXI*	*XXII*	*XXIII*	*XXIV*	*XXV*
Checklist for Analytical Cross-Sectional Studies (JBI Critical Appraisal Tool)																							
Were the criteria for inclusion in the sample clearly defined?	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
Were the study subjects and the setting described in detail?	+	+	+	+	+	+	-	+	-	-	-	+	-	-	-	+	-	+	+	+	-	-	+
Was the exposure measured in a valid way?	-	+	+	-	+	-	-	-	-	-	+	+	+	-	+	-	-	+	+	-	+	-	-
Was the exposure measured in a reliable way?	-	-	+	+	+	+	-	-	-	+	+	+	+	+	-	-	-	-	+	-	-	-	-
Were objective, standard criteria used for measurement of the condition?	-	+	+	-	+	-	-	-	-	+	+	+	+	-	+	-	-	+	-	+	+	-	-
Were confounding factors identified?	-	-	-	-	+	+	+	-	-	+	-	+	+	-	-	+	-	+	-	-	-	-	-
Were strategies to deal with confounding factors stated?	-	-	-	-	+	+	-	-	-	-	-	+	+	+	-	-	+	+	-	-	-	-	-
Were the outcomes measured in a valid way?	+	-	+	+	+	-	+	-	-	+	+	+	+	-	+	+	+	+	+	+	-	-	-
Were the outcomes measured in a reliable way?	+	-	+	+	+	+	+	+	+	-	+	-	+	+	-	+	-	-	+	-	+	-	-
Was appropriate statistical analysis used?	-	-	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	-	-	+
RISK OF BIAS	**H**	**H**	**L**	**M**	**L**	**M**	**L**	**H**	**L**	**M**	**M**	**L**	**L**	**L**	**S**	**M**	**S**	**L**	**M**	**H**	**H**	**H**	**H**

STUDY (selection ID)	*XXVII*	*XXVIII*	*XXIX*	*XXX*	*XXXI*	*XXXII*	*XXXIII*	*XXXIV*	*XXXV*	*XXXVI*	*XXXVII*	*XXXVIII*	*XXXIX*
Checklist for Analytical Cross-Sectional Studies (JBI Critical Appraisal Tool)													
Were the criteria for inclusion in the sample clearly defined?	+	+	+	+	+	+	+	+	+	-	-	+	-
Were the study subjects and the setting described in detail?	+	-	+	-	-	+	-	-	-	-	-	-	-
Was the exposure measured in a valid way?	-	-	-	-	-	-	+	-	-	-	-	-	-
Was the exposure measured in a reliable way?	-	+	-	-	+	-	-	+	-	-	+	-	-

Were objective, standard criteria used for measurement of the condition?	-	-	+	-	-	-	-	-	+	-	-	-	-
Were confounding factors identified?	+	-	+	-	-	-	-	-	+	-	-	+	+
Were strategies to deal with confounding factors stated?	+	+	+	-	-	+	-	-	+	-	-	-	-
Were the outcomes measured in a valid way?	+	-	+	-	+	+	+	+	+	+	+	-	+
Were the outcomes measured in a reliable way?	+	+	+	-	+	+	-	-	-	-	-	-	-
Was appropriate statistical analysis used?	+	-	+	+	+	+	+	+	+	+	+	+	-
RISK OF BIAS	**M**	**S**	**L**	**H**	**S**	**M**	**S**	**S**	**M**	**H**	**H**	**H**	**H**

Criteria were designated for each domain of methodology, internal validity, external validity and statistical methods. Each aspect of the score list was given a rating of '+' for an informative description of the item at issue and a study design meeting the quality standard, '-' for an informative description without a study design that met the quality standard, and '?' for insufficient information.

+ = yes
- = no
? = not specified/unclear
H – high risk of bias = 0-40%*
S – substantial risk of bias = 40-60%
M - moderate risk of bias = 60-80%
L – low risk of bias = 80-100%

Table S7. Quality assessment of the selected cohort study.

STUDY (selection ID)	*XI*
Checklist for Cohort Study (JBI Critical Appraisal Tool)	
Were the two groups similar and recruited from the same population?	+
Were the exposures measured similarly to assign people to both exposed and unexposed groups?	+
Was the exposure measured in a valid and reliable way?	-
Were confounding factors identified?	+
Were strategies to deal with confounding factors stated?	+
Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)?	-
Were the outcomes measured in a valid and reliable way?	+
Was the follow up time reported and sufficient to be long enough for outcomes to occur?	+
Was follow up complete, and if not, were the reasons to loss to follow up described and explored?	-
Were strategies to address incomplete follow up utilized?	-
Was appropriate statistical analysis used?	+
RISK OF BIAS	**M**

Criteria were designated for each domain of methodology, internal validity, external validity and statistical methods. Each aspect of the score list was given a rating of '+' for an informative description of the item at issue and a study design meeting the quality standard, '-' for an informative description without a study design that met the quality standard, and '?' for insufficient information.

+ = yes
- = no
? = not specified/unclear
H – high risk of bias = 0-40%*
S – substantial risk of bias = 40-60%
M - moderate risk of bias = 60-80%
L – low risk of bias = 80-100%

Table S8. Quality assessment of the selected randomized clinical trial.

STUDY (selection ID)	***XX***
Checklist for Randomized Clinical Trials (JBI Critical Appraisal Tool)	
Was true randomization used for assignment of participants to treatment groups?	-
Was allocation to treatment groups concealed?	+
Were treatment groups similar at the baseline?	+
Were participants blind to treatment assignment?	+
Were those delivering treatment blind to treatment assignment?	-
Were outcomes assessors blind to treatment assignment?	-
Were treatment groups treated identically other than the intervention of interest?	+
Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analyzed?	+
Were participants analyzed in the groups to which they were randomized?	+
Were outcomes measured in the same way for treatment groups?	+
Were outcomes measured in a reliable way?	+
Was appropriate statistical analysis used?	+
Was the trial design appropriate, and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?	+
RISK OF BIAS	**M**

Criteria were designated for each domain of methodology, internal validity, external validity and statistical methods. Each aspect of the score list was given a rating of '+' for an informative description of the item at issue and a study design meeting the quality standard, '-' for an informative description without a study design that met the quality standard, and '?' for insufficient information.

+ = yes
- = no
? = not specified/unclear
H – high risk of bias = 0-40%*
S – substantial risk of bias = 40-60%
M - moderate risk of bias = 60-80%
L – low risk of bias = 80-100%

Table S9. Quality assessment of the selected case-control study.

STUDY (selection ID)	***XXVI***
Checklist for Case-Control Studies (JBI Critical Appraisal Tool)	
Were the groups comparable other than the presence of disease in cases or the absence of disease in controls?	+
Were cases and controls matched appropriately?	+
Were the same criteria used for identification of cases and controls?	+
Was exposure measured in a standard, valid and reliable way?	-
Was exposure measured in the same way for cases and controls?	+
Were confounding factors identified?	-
Were strategies to deal with confounding factors stated?	-
Were outcomes assessed in a standard, valid and reliable way for cases and controls?	+
Was the exposure period of interest long enough to be meaningful?	-
Was appropriate statistical analysis used?	+
RISK OF BIAS	**M**

Criteria were designated for each domain of methodology, internal validity, external validity and statistical methods. Each aspect of the score list was given a rating of '+' for an informative description of the item at issue and a study design meeting the quality standard, '-' for an informative description without a study design that met the quality standard, and '?' for insufficient information.

+ = yes
- = no
? = not specified/unclear
H – high risk of bias = 0-40%*
S – substantial risk of bias = 40-60%
M - moderate risk of bias = 60-80%
L – low risk of bias = 80-100%

Table S10. Guidelines of PRISMA.

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	1
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	1,2
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	2
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	2
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	3
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	3
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	2
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	3
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	3
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	3
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	3

Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	4
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	-
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	4
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	4
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	4
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	4,5
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	6
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	-
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	-
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	6
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	6
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	6,7
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	7,8
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	10
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	10

Table S11. MOOSE checklist.

Item No	Recommendation	Reported on Page No
Reporting of background should include		
1	Problem definition	2
2	Hypothesis statement	2
3	Description of study outcome(s)	4
4	Type of exposure or intervention used	Online appendix
5	Type of study designs used	Online appendix
6	Study population	Online appendix
Reporting of search strategy should include		
7	Qualifications of searchers (eg, librarians and investigators)	3
8	Search strategy, including time period included in the synthesis and key words	3
9	Effort to include all available studies, including contact with authors	3
10	Databases and registries searched	3
11	Search software used, name and version, including special features used (eg, explosion)	-
12	Use of hand searching (eg, reference lists of obtained articles)	Figure 1
13	List of citations located and those excluded, including justification	Online appendix
14	Method of addressing articles published in languages other than English	-
15	Method of handling abstracts and unpublished studies	-
16	Description of any contact with authors	-
Reporting of methods should include		
17	Description of relevance or appropriateness of studies assembled for assessing the hypothesis to be tested	3
18	Rationale for the selection and coding of data (eg, sound clinical principles or convenience)	3

19	Documentation of how data were classified and coded (eg, multiple raters, blinding and interrater reliability)	-
20	Assessment of confounding (eg, comparability of cases and controls in studies where appropriate)	-
21	Assessment of study quality, including blinding of quality assessors, stratification or regression on possible predictors of study results	3,4
22	Assessment of heterogeneity	3
23	Description of statistical methods (eg, complete description of fixed or random effects models, justification of whether the chosen models account for predictors of study results, dose-response models, or cumulative meta-analysis) in sufficient detail to be replicated	4
24	Provision of appropriate tables and graphics	6
Reporting of results should include		
25	Graphic summarizing individual study estimates and overall estimate	6
26	Table giving descriptive information for each study included	Online appendix
27	Results of sensitivity testing (eg, subgroup analysis)	Online appendix
28	Indication of statistical uncertainty of findings	5,6

Modified from Stroup DF, Berlin JA, Morton SC, Olkin I, Williamson GD, Rennie D, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis Of Observational Studies in Epidemiology (MOOSE) group. JAMA 2000;283:2008–12

ReferenceList. References for online supportive information

1. Yoshizaki KT, Francisconi-dos-Rios LF, Sobral MAP, Aranha ACC, Mendes FM, Scaramucci T. Clinical features and factors associated with non-carious cervical lesions and dentin hypersensitivity. J Oral Rehabil [Internet]. 2017;44(2):112–8. Available from: http://doi.wiley.com/10.1111/joor.12469
2. Yang J, Cai D, Wang F, He D, Ma L, Jin Y, et al. Non-carious cervical lesions (NCCLs) in a random sampling community population and the association of NCCLs with occlusive wear. J Oral Rehabil. 2016;43(12):960–6.
3. BOMFIM RA, CROSATO E, MAZZILLI LEN, FRIAS AC. Prevalence and risk factors of non-carious cervical lesions related to occupational exposure to acid mists. Braz Oral Res [Internet]. 2015;29(1):1–8. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-83242015000100280&lng=en&tlng=en
4. Lai ZY, Zhi QH, Zhou Y, Lin HC. Prevalence of Non-carious Cervical Lesions and Associated Risk Indicators in Middle-aged and Elderly Populations in Southern China. Chinese J Dent Res. 2015;18(1):41–50.
5. Que K, Guo B, Jia Z, Chen Z, Yang J, Gao P. A cross-sectional study: Non-carious cervical lesions, cervical dentine hypersensitivity and related risk factors. J Oral Rehabil. 2013;40(1):24–32.
6. Jiang H, Du MQ, Huang W, Peng B, Bian Z, Tai BJ. The prevalence of and risk factors for non-carious cervical lesions in adults in Hubei Province, China. Community Dent Health [Internet]. 2011 Mar;28(1):22–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21485230
7. Tsiggos N, Tortopidis D, Hatzikyriakos A, Menexes G. Association between self-reported bruxism activity and occurrence of dental attrition, abfraction, and occlusal pits on natural teeth. J Prosthet Dent. 2008;100(1):41–6.
8. Smith WAJ, Marchan S, Rafeek RN. The prevalence and severity of non-carious cervical lesions in a group of patients attending a university hospital in Trinidad. J Oral Rehabil. 2008;35(2):128–34.
9. Kolak V, Pešić D, Melih I, Lalović M, Nikitović A, Jakovljević A. Epidemiological investigation of non-carious cervical lesions and possible etiological factors. J Clin Exp Dent. 2018;10(7):e648–56.
10. Hahn P, Reinhardt D, Schaller HG, Hellwig E. Root lesions in a group of 50-60 year-

old Germans related to clinical and social factors. Clin Oral Investig. 1999;3(4):168–74.

11. Reyes E, Hildebolt C, Langenwalter E, Miley D. Abfractions and Attachment Loss in Teeth With Premature Contacts in Centric Relation: Clinical Observations. J Periodontol [Internet]. 2009;80(12):1955–62. Available from: http://www.joponline.org/doi/10.1902/jop.2009.090149
12. Ringelberg ML, Gilbert GH, Antonson DE, Dolan TA, Legler DW, Foerster U, et al. Root caries and root defects in urban and rural adults: the Florida Dental Care Study. J Am Dent Assoc [Internet]. 1996 Jul;127(7):885–91. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8754463
13. Akgül HM, Akgül N, Karaoglanoglu S, Ozdabak N. A survey of the correspondence between abrasions and tooth brushing habits in Erzurum, Turkey. Int Dent J [Internet]. 2003 Dec;53(6):491–5. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14725378
14. Bernhardt O, Gesch D, Schwahn C, Mack F, Meyer G, John U, et al. Epidemiological evaluation of the multifactorial aetiology of abfractions. J Oral Rehabil [Internet]. 2006 Jan;33(1):17–25. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16409512
15. Brandini DA, de Sousa ALB, Trevisan CI, Pinelli LAP, do Couto Santos SC, Pedrini D, et al. Noncarious cervical lesions and their association with toothbrushing practices: in vivo evaluation. Oper Dent [Internet]. 2011;36(6):581–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21913861
16. Estafan A, Furnari PC, Goldstein G, Hittelman EL. In vivo correlation of noncarious cervical lesions and occlusal wear. J Prosthet Dent [Internet]. 2005 Mar;93(3):221–6. Available from: http://linkinghub.elsevier.com/retrieve/pii/S002239130400825X
17. Lussi A, Schaffner M, Hotz P, Suter P. Dental erosion in a population of Swiss adults. Community Dent Oral Epidemiol [Internet]. 1991 Oct;19(5):286–90. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1742995
18. 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. J Prosthet Dent [Internet]. 2007 Aug;98(2):150–8. Available from: http://linkinghub.elsevier.com/retrieve/pii/S0022391307600481
19. Pegoraro LF, Scolaro JM, Conti PC, Telles D, Pegoraro TA. Noncarious cervical lesions in adults: prevalence and occlusal aspects. J Am Dent Assoc [Internet]. 2005 Dec;136(12):1694–700. Available from:

http://www.ncbi.nlm.nih.gov/pubmed/16383052

20. Radentz WH, Barnes GP, Cutright DE. A Survey of Factors Possibly Associated With Cervical Abrasion of Tooth Surfaces. J Periodontol [Internet]. 1976 Mar;47(3):148–54. Available from: http://doi.wiley.com/10.1902/jop.1976.47.3.148

21. Bergström J, Lavstedt S. An epidemiologic approach to toothbrushing and dental abrasion. Community Dent Oral Epidemiol [Internet]. 1979 Feb;7(1):57–64. Available from: http://www.ncbi.nlm.nih.gov/pubmed/282958

22. Sangnes G, Gjermo P. Prevalence of oral soft and hard tissue lesions related to mechanical toothcleansing procedures. Community Dent Oral Epidemiol [Internet]. 1976 Mar;4(2):77–83. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1062255

23. Takehara J, Takano T, Akhter R, Morita M. Correlations of noncarious cervical lesions and occlusal factors determined by using pressure-detecting sheet. J Dent [Internet]. 2008 Oct;36(10):774–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/18597913

24. Telles D, Pegoraro LF, Pereira JC. Incidence of noncarious cervical lesions and their relation to the presence of wear facets. J Esthet Restor Dent [Internet]. 2006;18(4):178–83; discussion 184. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16911416

25. Piotrowski BT, Gillette WB, Hancock EB. Examining the prevalence and characteristics of abfractionlike cervical lesions in a population of U.S. veterans. J Am Dent Assoc [Internet]. 2001;132(12):1694–701. Available from: http://dx.doi.org/10.14219/jada.archive.2001.0122

26. Antonelli JR, Hottel TL, Brandt R, Scarbecz M, Patel T. The role of occlusal loading in the pathogenesis of non-carious cervical lesions. Am J Dent. 2013;26(2):86–92.

27. Palomino-Gómez SP, Jeremias F, Finoti LS, Paredes-Coz G, Raveli DB. Influence of lateral excursion on vestibular cervical dental abfraction. Acta Odontol Latinoam [Internet]. 2011;24(3):283–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/22550823

28. Pikdöken L, Akca E, Gürbüzer B, Aydil B, Taşdelen B. Cervical wear and occlusal wear from a periodontal perspective. J Oral Rehabil [Internet]. 2011 Feb;38(2):95–100. Available from: http://www.ncbi.nlm.nih.gov/pubmed/20678102

29. Ahmed H, Durr-E-Sadaf, Rahman M. Factors associated with Non-Carious Cervical Lesions (NCCLs) in teeth. J Coll Physicians Surg Pak [Internet]. 2009 May;19(5):279–82. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19409158

30. Oginni AO, Olusile AO, Udoye CI. Non-carious cervical lesions in a Nigerian

population: Abrasion or abfraction? Int Dent J. 2003;53(5):275–9.
31. Miller N, Penaud J, Ambrosini P, Bisson-Boutelliez C, Briançon S. Analysis of etiologic factors and periodontal conditions involved with 309 abfractions. J Clin Periodontol. 2003;30(9):828–32.
32. Aw TC, Lepe X, Johnson GH, Mancl L. Characteristics of noncarious cervical lesions: a clinical investigation. J Am Dent Assoc [Internet]. 2002 Jun;133(6):725–33. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12083648
33. Teixeira DNR, Zeola LF, Machado AC, Gomes RR, Souza PG, Mendes DC, et al. Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: A cross-sectional study. J Dent. 2018;76.
34. Sugita I, Nakashima S, Ikeda A, Burrow MF, Nikaido T, Kubo S, et al. A pilot study to assess the morphology and progression of non-carious cervical lesions. J Dent [Internet]. 2017;57(2017):51–6. Available from: http://dx.doi.org/10.1016/j.jdent.2016.12.004
35. Sawlani K, Lawson NC, Burgess JO, Lemons JE, Kinderknecht KE, Givan DA, et al. Factors influencing the progression of noncarious cervical lesions: A 5-year prospective clinical evaluation. J Prosthet Dent [Internet]. 2016;115(5):571–7. Available from: http://dx.doi.org/10.1016/j.prosdent.2015.10.021
36. Wood ID, Kassir ASA, Brunton PA. Effect of Lateral Excursive Movements on the Progression of Abfraction Lesions. Oper Dent [Internet]. 2009;34(3):273–9. Available from: http://www.jopdentonline.org/doi/10.2341/08-100
37. Afolabi AO, Shaba OP, Adegbulugbe IC. Distribution and characteristics of non carious cervical lesions in an adult Nigerian population. Nig Q J Hosp Med [Internet]. 2012;22(1):1–6. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23175871
38. Afolabi AO, Shaba OP, Adegbulugbe IC. Clinical investigation of patient related factors in non carious cervical lesions. Nig Q J Hosp Med [Internet]. 2013;23(2):129–34. Available from: http://www.ncbi.nlm.nih.gov/pubmed/24579510
39. Nieri M, Pini Prato GP, Giani M, Magnani N, Pagliaro U, Roberto R. Patient perceptions of buccal gingival recessions and requests for treatment. J Clin Periodontol. 2013;40(7):707–12.
40. Wada I, Shimada Y, Ikeda M, Sadr A, Nakashima S, Tagami J, et al. Clinical assessment of non carious cervical lesion using swept-source optical coherence tomography. J Biophotonics. 2015;8(10):846–54.

41. Mamaladze M, Khutsishvili L, Zarkua E. DISTRIBUTION OF CARIOUS AND NON-CARIOUS CERVICAL LESIONS AND GINGIVAL RECESSION AT AGE RELATED ASPECTS. Georgian Med News [Internet]. 2016 Jul;(256–257):18–23. Available from: http://www.ncbi.nlm.nih.gov/pubmed/27661270
42. Haralur, Alqahtani, AlMazni, Alqahtani. Association of Non-Carious Cervical Lesions with Oral Hygiene Habits and Dynamic Occlusal Parameters. Diagnostics [Internet]. 2019 Apr 12;9(2):43. Available from: https://www.mdpi.com/2075-4418/9/2/43
43. Naik VK, Jacob CA, Nainar DA. Assessment of non-carious root surface defects in areas of gingival recession: A descriptive study. J Clin Exp Dent. 2016;18(4):397–402.
44. Young WG, Khan F. Sites of dental erosion are saliva dependent. J Oral Rehabil. 2002;29:35–43.
45. Khan F, Shahabi S. Dental cervical lesions associated with occlusal. Aust Dent J. 1999;(3):176–86.
46. Sadaf D, Ahmad Z. Role of brushing and occlusal forces in non-carious cervical lesions (NCCL). Int J Biomed Sci. 2014;10(4):265–8.
47. Addy M, Shellis RP. Interaction between Attrition,Abrasion and Erosion in Tooth Wear. Dent Eros [Internet]. 2006;20:17–31. Available from: https://www.karger.com/Article/FullText/93348
48. Shellis RP, Addy M. The Interactions between Attrition, Abrasion and Erosion in Tooth Wear. In 2014. p. 32–45. Available from: https://www.karger.com/Article/FullText/359936
49. Wiegand A, Schlueter N. The Role of Oral Hygiene: Does Toothbrushing Harm? In 2014. p. 215–9. Available from: https://www.karger.com/Article/FullText/360379
50. Robertson PB, Walsh MM, Greene JC. Oral effects of smokeless tobacco use by professional baseball players. Adv Dent Res [Internet]. 1997 Sep;11(3):307–12. Available from: http://www.ncbi.nlm.nih.gov/pubmed/9524430
51. Kontaxopoulou I, Alam S. Risk Assessment for Tooth Wear. Prim Dent J [Internet]. 2015;4(3):25–9. Available from: http://openurl.ingenta.com/content/xref?genre=article&issn=2050-1684&volume=4&issue=3&spage=25
52. Bader JD, McClure F, Scurria MS, Shugars DA, Heymann HO. Case-control study of non-carious cervical lesions. Community Dent Oral Epidemiol [Internet]. 1996 Aug;24(4):286–91. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8871039
53. Alvarez-Arenal A, Alvarez-Menendez L, Gonzalez-Gonzalez I, Alvarez-Riesgo JA,

Brizuela-Velasco A, DeLlanos-Lanchares H. Non-carious cervical lesions and risk factors: a case-control study. J Oral Rehabil [Internet]. 2018 Sep 25; Available from: http://www.ncbi.nlm.nih.gov/pubmed/30252966

54. Rahiotis C, Polychronopoulou A, Tsiklakis K, Kakaboura A. Cervical dentin hypersensitivity: A cross-sectional investigation in Athens, Greece. J Oral Rehabil. 2013;40(12):948–57.

55. Kopycka-Kedzierawski DT, Meyerowitz C, Litaker MS, Chonowski S, Heft MW, Gordan V V., et al. Management of Dentin Hypersensitivity by National Dental Practice-Based Research Network practitioners: Results from a questionnaire administered prior to initiation of a clinical study on this topic. BMC Oral Health [Internet]. 2017;17(1):1–7. Available from: http://dx.doi.org/10.1186/s12903-017-0334-0

56. Walls AWG, Silver PT, Steele JG. Impact of treatment provision on the epidemiological recording of root caries. Eur J Oral Sci. 2000;108(1):3–8.

57. da Silva AMBR, Valencise Magri L, da Silva MAMR, Sousa Neto MD de. Are the bite force and electromyographic activity altered in muscle TMD patients with abfraction lesions? Cranio - J Craniomandib Pract [Internet]. 2017;9634(November):1–7. Available from: http://doi.org/10.1080/08869634.2017.1407116

58. Kumar S, Kumar A, Debnath N, Kumar A, K. Badiyani B, Basak D, et al. Prevalence and risk factors for non-carious cervical lesions in children attending special needs schools in India. J Oral Sci [Internet]. 2015;57(1):37–43. Available from: https://www.jstage.jst.go.jp/article/josnusd/57/1/57_37/_article

59. Borcic J, Anic I, Urek MM, Ferreri S. The prevalence of non-carious cervical lesions in permanent dentition. J Oral Rehabil [Internet]. 2004;31(2):117–23. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15009594

60. Zuza A, Racic M, Ivkovic N, Krunic J, Stojanovic N, Bozovic D, et al. Prevalence of non-carious cervical lesions among the general population of the Republic of Srpska, Bosnia and Herzegovina. Int Dent J [Internet]. 2019 Feb 7;idj.12462. Available from: https://onlinelibrary.wiley.com/doi/abs/10.1111/idj.12462

61. Sälzer S, Slot DE, Van der Weijden FA, Dörfer CE. Efficacy of inter-dental mechanical plaque control in managing gingivitis - a meta-review. J Clin Periodontol [Internet]. 2015 Apr;42:S92–105. Available from: http://doi.wiley.com/10.1111/jcpe.12363

62. Teixeira DNR, Thomas RZ, Soares PV, Cune MS, Gresnigt MMM, Slot DE.

Prevalence of noncarious cervical lesions among adults: A systematic review. J Dent [Internet]. 2020 Apr;95:103285. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571220300191

63. Grippo JO, Simring M, Coleman TA. Abfraction, abrasion, biocorrosion, and the enigma of noncarious cervical lesions: A 20-year perspective. J Esthet Restor Dent. 2012;24(1):10–23.

64. Grippo JO, Simring M, Schreiner S. Attrition, abrasion, corrosion and abfraction revisited: A new perspective on tooth surface lesions. J Am Dent Assoc [Internet]. 2004;135(8):1109–18. Available from: http://dx.doi.org/10.14219/jada.archive.2004.0369

65. Bartlett DW, Shah P. A Critical Review of Non-carious Cervical (Wear) Lesions and the Role of Abfraction, Erosion, and Abrasion. J Dent Res [Internet]. 2006 Apr 13;85(4):306–12. Available from: http://journals.sagepub.com/doi/10.1177/154405910608500405

66. Bartlett D. Etiology and prevention of acid erosion. Compend Contin Educ Dent [Internet]. 2009;30(9):616–20. Available from: http://www.ncbi.nlm.nih.gov/pubmed/19998728

67. Barron RP, Carmichael RP, Marcon MA, Sàndor GKB. Dental erosion in gastroesophageal reflux disease. J Can Dent Assoc [Internet]. 2003 Feb;69(2):84–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/12559056

68. Dawes C. What is the critical pH and why does a tooth dissolve in acid? J Can Dent Assoc [Internet]. 2003 Dec;69(11):722–4. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14653937

69. Heasman PA, Holliday R, Bryant A, Preshaw PM. Evidence for the occurrence of gingival recession and non-carious cervical lesions as a consequence of traumatic toothbrushing. J Clin Periodontol. 2015;42(S16):S237–55.

70. Auad S, Moynihan P. Diet and dental erosion. Quintessence Int [Internet]. 2007 Feb;38(2):130–3. Available from: http://www.ncbi.nlm.nih.gov/pubmed/17263152

71. Kitchens M, Owens B. Effect of Carbonated Beverages, Coffee, Sports and High Energy Drinks, and Bottled Water on the in vitro Erosion Characteristics of Dental Enamel. J Clin Pediatr Dent [Internet]. 2007 Apr 1;31(3):153–9. Available from: https://meridian.allenpress.com/jcpd/article/31/3/153/78456/Effect-of-Carbonated-Beverages-Coffee-Sports-and

72. Wongkhantee S, Patanapiradej V, Maneenut C, Tantbirojn D. Effect of acidic food and

drinks on surface hardness of enamel, dentine, and tooth-coloured filling materials. J Dent [Internet]. 2006 Mar;34(3):214–20. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571205001223

73. Bartlett DW, Evans DF, Anggiansah A, Smith BG. A study of the association between gastro-oesophageal reflux and palatal dental erosion. Br Dent J [Internet]. 1996 Aug 24;181(4):125–31. Available from: http://www.nature.com/articles/4809187

74. Moazzez R, Bartlett D, Anggiansah A. Dental erosion, gastro-oesophageal reflux disease and saliva: how are they related? J Dent [Internet]. 2004 Aug;32(6):489–94. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571204000661

75. Rees JS. The biomechanics of abfraction. Proc Inst Mech Eng Part H J Eng Med [Internet]. 2006 Jan 17;220(1):69–80. Available from: http://journals.sagepub.com/doi/10.1243/095441105X69141

76. BORCIC J, ANIC I, SMOJVER I, CATIC A, MILETIC I, RIBARIC SP. 3D finite element model and cervical lesion formation in normal occlusion and in malocclusion. J Oral Rehabil [Internet]. 2005 Jul;32(7):504–10. Available from: http://doi.wiley.com/10.1111/j.1365-2842.2005.01455.x

77. Grippo JO. Noncarious cervical lesions: the decision to ignore or restore. J Esthet Dent [Internet]. 1992;4 Suppl:55–64. Available from: http://www.ncbi.nlm.nih.gov/pubmed/1298328

78. Briggs Institute Joanna T. Joanna Briggs Institute Reviewer's Manual. Adelaide: The Joanna Briggs Institute; 2014.

79. Rusu Olaru A, Popescu MR, Dragomir LP, Rauten AM. Clinical Study on Abfraction Lesions in Occlusal Dysfunction. Curr Heal Sci J [Internet]. 45(4):390–7. Available from: http://www.ncbi.nlm.nih.gov/pubmed/32110441

80. Rusu Olaru A, Popescu MR, Dragomir LP, Popescu DM, Arsenie CC, Rauten AM. Identifying the Etiological Factors Involved in the Occurrence of Non-Carious Lesions. Curr Heal Sci J [Internet]. 45(2):227–34. Available from: http://www.ncbi.nlm.nih.gov/pubmed/31624652

81. Teixeira DNR, Zeola LF, Machado AC, Gomes RR, Souza PG, Mendes DC, et al. Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: a cross-sectional study. J Dent [Internet]. 2018;(June):1–5. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0300571218301805%0Ahttp://www.ncbi.nlm.nih.gov/pubmed/29940290

82. Marinescu IR, Popescu SM, Răghici EC, Scrieciu M, Mercuț V, Turcu AA, et al. Etiological Aspects of Noncarious Dental Lesions. Curr Heal Sci J [Internet]. 43(1):54–61. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30595855
83. Antonelli JR, Hottel TL, Garcia-Godoy F. Abfraction lesions--where do they come from? A review of the literature. J Tenn Dent Assoc [Internet]. 2013;93(1):11–4. Available from: http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=23909084%5Cnhttp://www.ncbi.nlm.nih.gov/pubmed/23909084
84. Brandini DA, Trevisan CL, Panzarini SR, Pedrini D. Clinical evaluation of the association between noncarious cervical lesions and occlusal forces. J Prosthet Dent [Internet]. 2012 Nov;108(5):298–303. Available from: http://www.ncbi.nlm.nih.gov/pubmed/23107237
85. Hirata Y, Yamamoto T, Kawagoe T, Sasaguri K, Sato S. Relationship between occlusal contact pattern and non-carious cervical lesions among male adults. Int J Stomatol Occlusion Med [Internet]. 2010 Mar 23;3(1):10–4. Available from: http://link.springer.com/10.1007/s12548-010-0039-3
86. telles daniel, Pegoraro luiz fernando, Pereira jose carlos. Incidence of Noncarious Cervical Lesions and Their Relation to the Presence of Wear Facets. J Esthet Restor Dent [Internet]. 2006 Jul;18(4):178–83. Available from: http://doi.wiley.com/10.1111/j.1708-8240.2006.00015.x
87. TELLES D, PEGORARO LF, PEREIRA JC. Prevalence of Noncarious Cervical Lesions and Their Relation to Occlusal Aspects: A Clinical Study. J Esthet Restor Dent [Internet]. 2000 Jan;12(1):10–5. Available from: http://doi.wiley.com/10.1111/j.1708-8240.2000.tb00193.x
88. Guyatt GH, Oxman AD, Montori V, Vist G, Kunz R, Brozek J, et al. GRADE guidelines: 5. Rating the quality of evidence—publication bias. J Clin Epidemiol [Internet]. 2011 Dec;64(12):1277–82. Available from: https://linkinghub.elsevier.com/retrieve/pii/S0895435611001818
89. Smith BG, Knight JK. An index for measuring the wear of teeth. Br Dent J [Internet]. 1984 Jun 23;156(12):435–8. Available from: http://www.ncbi.nlm.nih.gov/pubmed/6590081
90. Smith BG, Robb ND. The prevalence of toothwear in 1007 dental patients. J Oral Rehabil [Internet]. 1996 Apr;23(4):232–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/8730269

91. SENNA P, DEL BEL CURY A, RÖSING C. Non-carious cervical lesions and occlusion: a systematic review of clinical studies. J Oral Rehabil [Internet]. 2012 Jun;39(6):450–62. Available from: http://doi.wiley.com/10.1111/j.1365-2842.2012.02290.x

92. Brandini DA, de Sousa ALB, Trevisan CI, Pinelli LAP, do Couto Santos SC, Pedrini D, et al. Noncarious cervical lesions and their association with toothbrushing practices: in vivo evaluation. Oper Dent [Internet]. 36(6):581–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/21913861

93. Khan F, Young WG, Shahabi S, Daley TJ. Dental cervical lesions associated with occlusal erosion and attrition. Aust Dent J [Internet]. 1999 Sep;44(3):176–86. Available from: http://doi.wiley.com/10.1111/j.1834-7819.1999.tb00219.x

94. Azevedo AM de, Panzeri H, Prado CJ do, De-Mello JDB, Soares CJ, Fernandes-Neto AJ. Assessment in vitro of brushing on dental surface roughness alteration by laser interferometry. Braz Oral Res [Internet]. 2008 Mar;22(1):11–7. Available from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S1806-83242008000100003&lng=en&tlng=en

95. Litonjua LA, Andreana S, Bush PJ, Tobias TS, Cohen RE. Wedged cervical lesions produced by toothbrushing. Am J Dent [Internet]. 2004 Aug;17(4):237–40. Available from: http://www.ncbi.nlm.nih.gov/pubmed/15478482

96. Faye B, Kane AW, Sarr M, Lo C, Ritter A V, Grippo JO. Noncarious cervical lesions among a non-toothbrushing population with Hansen’s disease (leprosy): initial findings. Quintessence Int [Internet]. 2006 Sep;37(8):613–9. Available from: http://www.ncbi.nlm.nih.gov/pubmed/16922020

97. Pashley DH. How can sensitive dentine become hypersensitive and can it be reversed? J Dent [Internet]. 2013 Jul;41:S49–55. Available from: https://linkinghub.elsevier.com/retrieve/pii/S030057121370006X

98. da Silva AMBR, Valencise Magri L, da Silva MAMR, Sousa Neto MD de. Are the bite force and electromyographic activity altered in muscle TMD patients with abfraction lesions? CRANIO® [Internet]. 2019 May 4;37(3):168–74. Available from: https://www.tandfonline.com/doi/full/10.1080/08869634.2017.1407116

99. Igarashi Y, Yoshida S, Kanazawa E. The prevalence and morphological types of non-carious cervical lesions (NCCL) in a contemporary sample of people. Odontology. 2017;105(4):443–52.

100. Srisilapanan P, Jindarat M, Roseman J. The Prevalence and Severity of Tooth Wear in

Type 2 Diabetic Patients. Int J Dent [Internet]. 2018 Dec 11;2018:1–5. Available from: https://www.hindawi.com/journals/ijd/2018/3608158/

Capítulo 3

Original research: ***Influence of stress distribution on the origin of noncarious cervical lesions and gingival recession with different bone attachment levels***

Peres TS, Teixeira DNR, Machado AC, Zeola LF, Soares PV.

Title: Influence of stress distribution on the development of noncarious cervical lesions with different bone attachment levels

Título: Influência da distribuição de tensão no desenvolvimento de lesões cervicais não cariosas com diferentes níveis de inserção óssea

Authors:

Thiago Silva Peres[1], Daniela Navarro Ribeiro Teixeira[2]; Paulo Vinicius Soares[3]; Livia Favaro Zeola[4;] Alexandre Coelho Machado[5]

[1]Graduate Student and Member of Nucleus Extension, Research and Teaching at NCCL, Dentistry School, Federal University of Uberlandia, Brazil;

[2]Postgraduate Student and Member of Nucleus Extension, Research and Teaching at NCCL, Dentistry School, Federal University of Uberlandia, Brazil;

[3]Associate Professor at Operative Dentistry and Dental Materials Department and Coordinator of Nucleus Extension, Research and Teaching at NCCL, Dentistry School, Federal University of Uberlandia, Brazil;

[4]Professor at Operative Dentistry, Dentistry School, Federal University of Minas Gerais and Member of Nucleus Extension, Research and Teaching at NCCL, Dentistry School, Federal University of Uberlandia, Brazil;

[5]Professor at Technical Health School and Coordinator of Nucleus Extension, Research and Teaching at NCCL, Dentistry School, Federal University of Uberlandia, Brazil;

Corresponding author:

Alexandre Coelho Machado

Technical Health School – Federal University of Uberlandia

E-mail: alexandrecoelhomachado@gmail.com

Keywords: noncarious cervical lesion, finite element analysis, gingival recession, bone attachment level.

ABSTRACT

The aim of this study was to evaluate the influence of the stress distribution pattern on maxillary premolars with noncarious cervical lesions (NCCLs) with different levels of bone attachment, anteriorly and posteriorly to the NCCL restorative procedure. Three-dimensional models of maxillary premolars were generated. Beyond the sound model were generated a model with NCCL. To these models were generated three models with bone loss: normal bone level, vertical bone loss and horizontal bone loss. Composite resin restoration of the model with NCCL was simulated. To each model three different loads with 100 N were applied: vertical load (VL), buccal load (BL) and palatine load (PL). The stress data were obtained in MPa and the values were obtained on Maximum Principal Stress on one node on the meshed buccal surface and on Minimum Principal Stress on one mesh node for analyses of the crestal bone. Maximum principal stress results showed clearly that bone loss does not influence on the stress concentration on cementum enamel junction. For minimum principal stress, the buccal load cause higher compressive stress on bone vestibular surface. The bone stress is not dependent of the presence or absence of NCCL and of the restoration procedure. The occlusal load is key factor for the origin and development of bone loss and NCCL.

Keywords: noncarious cervical lesion, finite element analysis, gingival recession, bone attachment level.

RESUMO

O objetivo deste estudo foi avaliar a influência do padrão de distribuição do estresse nos pré-molares superiores com lesões cervicais não cariosas (LCNCs), com diferentes níveis de inserção óssea, anterior e posteriormente ao procedimento restaurador da LCNC. Para esta análise, foram gerados modelos tridimensionais de pré-molares superiores. A partir do modelo hígido, foi gerado um modelo com LCNC. Para esses modelos foram gerados três modelos com perda óssea: nível ósseo normal, perda óssea vertical e perda óssea horizontal. A restauração de resina composta do modelo com LCNC foi simulada. Para cada modelo foram aplicadas três cargas diferentes com 100 N: carregamento axial (VL), carregamento vestibular (BL) e carregamento palatino (PL). Os dados foram obtidos em MPa, os valores de tensão foram obtidos pelo critério de tensão máxima principal em um nó da superfície vestibular e o valor da tensão mínima principal foi obtido em um nó para análises da crista óssea vestibular. Para os resultados de tensão máxima principal, a perda óssea não influenciou na distribuição de tensão ao nível da junção amelo-dentinária; para o critério de tensão mínima principal. O carregamento vestibular promoveu maior tensão compressiva na superfície óssea vestibular. A concentração de tensão ao nível ósseo independe da presença ou ausência de LCNC e do procedimento de restauração. O tipo de contato oclusal é fator chave para o desenvolvimento da perda óssea e origem e progressão da LCNC.

Palavras-chaves: lesão cervical não cariosa, método de elementos finitos, recessão gengival, nível de inserção óssea

INTRODUCTION

The worldwide prevalence of noncarious cervical lesions (NCCLs) among adults is 46.7% and higher in older populations than in younger ones (Teixeira et al. 2020). The NCCLs are pathological conditions characterized by the loss of tooth structure at the cemento-enamel junction (CEJ), unrelated to bacterial process (Borcic et al. 2004; Michael et al. 2009; Reyes et al. 2009). This tooth structure loss is routinely found and increasingly common in dental clinical practice (Borcic, Anic, Urek and Ferreri 2004; Michael, Townsend, Greenwood and Kaidonis 2009; Rees 2002; Reyes, Hildebolt, Langenwalter and Miley 2009), presenting a positive correlation with the presence of gingival recession (GR) (Teixeira et al. 2018) and its aetiology is considered multifactorial. The three mechanisms involved in these lesions development are stress (abfraction), friction (wear) and biocorrosion (chemical, biochemical and electrochemical degradation) (Grippo et al. 2012). NCCLs also increase with age, which suggests a fatigue component in their formation associated with occlusal interferences or any event that changes the dental occlusion, such as restorative procedures, tooth occlusal surface wear, altered tooth position and toothbrushing behavior (Bernhardt et al. 2006).

One of the major factors that contributes to NCCLs and GR progression is excessive loading associated with occlusal forces (Dejak and Mlotkowski 2011; Rees 2000). Two types of loading on premolars have been described (Soares et al. 2015; Soares et al. 2014): oblique load (due to oblique or inclined contact with the lingual/buccal surface) and vertical load (along the long axis of the tooth, applied via incisal edge). Dental biomechanical behavior, when submitted to oblique loads, has an alteration in stress-strain distribution pattern (Ichim et al. 2007), resulting in fatigue and rupture of rigid structures such as enamel.

Oblique loads can also influence the loss of alveolar bone and it can be a pathologic or age-related phenomenon. Although 0.017 mm/year of alveolar bone loss is considered quite normal (Corn and Marks 1989), greater amounts of bone resorption can be found in a few adults without any diagnosable pathologic condition. Several studies have investigated stress distributions and displacement patterns in teeth with different amounts of alveolar bone loss (Cobo et al. 1996; Cobo et al. 1993; Geramy 2000; Wood et al. 2008). However, no study evaluated the relationship between bone loss and the development of noncarious cervical lesions.

The multifactorial characteristics of NCCLs must be considered while developing a multidisciplinary treatment for these lesions (Teixeira, Zeola, Machado, Gomes, Souza, Mendes and Soares 2018). Although the literature is not clear about the treatment protocol (Kim et al. 2009), it is notorious that the longevity of the rehabilitation consists on the restoration of lost structures, occlusal analysis and education to patients about their habits. The restoration is recommended as a protection against cervical dentin hypersensitivity, prevention of excessive wear and improvement of aesthetic standards requirements (Soares et al. 2013), and especially to minimize damage to the dental structure due the alterations in the stress strain distribution (Poiate et al. 2009).

Methods that use simulated dental structures are useful to analyze the dental behavior associated with structural loss, occlusal conditions and the effects of restorative materials, taking into account their properties (Poiate, Vasconcellos, Poiate Junior and Dias 2009). The finite element analysis (FEA) method provides the analysis of the biomechanical behavior of teeth in specific clinical situations, to understand failures causes, treatment protocols and pathological alterations (Borcic et al. 2005; Poiate, Vasconcellos, Poiate Junior and Dias 2009; Rees 2002; Vasudeva and Bogra 2008).

Thus, the aim of this study was to evaluate the influence of stress distribution pattern in a maxillary premolar with NCCLs and different levels of alveolar bone loss, submitted to three different occlusal loadings as well as their restored status using three-dimensional (3D) finite element analysis. The null hypothesis is that bone attachment, restorative procedure and occlusal loads do not interfere on the biomechanical behavior of the tooth.

MATERIALS AND METHODS

Three-dimensional homogeneous linear elastic finite element analysis was performed using anatomically based geometric representations for pulp, dentin, enamel, periodontal ligament, and cortical and medullary bones (Soares, Santos-Filho, Soares, Faria, Naves, Michael, Kaidonis, Ranjitkar and Townsend 2013). Nine computer-aided design (CAD) models were generated (Rhinoceros 3D software, Rhinoceros, Miami, FL, USA) differing the cervical region (sound tooth-SO, unrestored buccal wedge-shaped NCCL-UN and NCCL restored with composite resin-CR) and the level of bone loss (normal-NO, vertical-VE and horizontal-HO.

The models were exported to the processing analysis software (ANSYS 12.0, Ansys Workbench 12.0.1, Canonsburg, PA, USA) using the Standard for the Exchange of Product Data (STEP) format. The following steps were performed in this software: preprocessing (definition of mechanical properties, volumes, connection types, mesh for each structure, and boundary conditions), processing (data calculation), and post-processing (analysis of results by stress distribution criteria). Enamel and dentin were considered orthotropic and the other structures isotropic (Table 1) (Carter and Hayes 1977; Miura et al. 2009; Rubin et al. 1983; Shinya et al. 2008; Weinstein et al. 1980).

After testing the mesh conversion to define the appropriate mesh refinement level, volumes corresponding to each structure were meshed with controlled and connected elements. The meshing process involved division of the studied system into a set of small discrete elements defined by nodes. Solid quadratic tetrahedral elements of 10 nodes were used. The mesh conversion test was initiated using the software automatic meshing and was continued by gradually decreasing the size of the elements. For each test stage, the results were generated by equivalent stress criterion (von Mises) to verify the higher stress values of dentin. The mesh was considered satisfactory when, even reducing the dimension of elements, the higher stress levels were similar to the results observed with the previous mesh refinement. The number of elements used varied depending on the different volumes, so that the final model accurately represented the original geometry. Due to the adhesive properties of the composite resin and adhesive system, the restoration was bonded to dental structures by considering a mesh connection with dentin and enamel.

After the mesh step, boundary conditions were determined. The models underwent three types of loads (100N) applied on specific surfaces previously defined in CAD Software. Vertical Load (VL) was distributed equally on both cusps, simulating homogeneous contact distribution. Buccal Load (BL) and Palatine Load (PL) was applied at 45 degrees to the long axis on buccal and palatine cusps respectively, simulating occlusal interferences (Rees 2002). Models were constrained on the lateral and base of cortical and trabecular bone to avoid the displacement (Zeola et al. 2015).

The stress distribution analyses were recorded using the Maximum and Minimum Principal Stress criteria, measured in MPa. For the 3D images perspectives, the composite resin was plotted in transparency for better understanding of the NCCLs walls. On the sagittal analyses, the composite resin was plotted to identify the stress on the restorative material. For analysis of the cervical region, stress values were obtained on Maximum Principal Stress on one node of meshed on the buccal surface. Similarly, the stress value on Minimum Principal Stress was obtained on one node of meshed for analysis to the buccal crestal bone.

RESULTS

The stress distribution between all the models under different loading conditions is shown in Figures 1-4.

Maximum principal stress results showed clearly that bone loss does not influence on the appearance of NCCLs. The stress distribution was quite the same on axial, buccal or palatine load in sound teeth, teeth with NCCL and restored NCCL. The presence or absence of restoration did not influence on the bone strain either. However, the bone loss modified the stress field, causing it to be concentrated closer to the bone, displacing the point of fulcrum.

To the palatine load, was observed in the Fig. 5 higher values of tensile stress in the cervical region for all models, than the models that received axial and vertical load. The results observed in the Fig. 6 showed that the models with horizontal bone loss when submitted to the vertical load had higher values of compression stress on the region of crestal bone than the models with NCCL and sound teeth. Loading direction made significant difference on the stress distribution pattern. The loading type has influence on the bone loss and on the progression of NCCL. As can be noticed on the figures, the axial load provides more homogeneous stress distribution between tooth and bone. The palatine load causes tensile stress on buccal surface, which increases the chances of NCCL progression. On the other hand, the buccal load causes compressive stress on vestibular surface, but it also causes compressive stress on crestal bone.

The bone stress distribution pattern is independent of presence or absence of NCCL. The only thing that will change with the bone loss is the point of fulcrum, which will dislocate. The stress distribution of the lesion remains the same. Thus, the major factor to modify the stress field is still the occlusal contact. The presence of restoration also does not interfere on the stress pattern related to the bone loss. It only improves the stress distribution in non-axial loading.

DISCUSSION

According to the results, the null hypothesis of this study was rejected. The different bone attachment, NCCL restorative procedure and occlusal load promoted changes on the biomechanical behavior of maxillary premolars. The results showed that the loading type has influence on the bone loss and on the progression of NCCL. However, the bone stress distribution pattern is independent of presence or absence of NCCL. The restored 3D model also did not interfere on the stress pattern related to the bone loss. In the analysis of pattern stress on the models that received palatine load, the results showed lower values of Maximum Principal Stress in restored than in non-restored models, with NCCL. Such thing occurs because the point evaluated was in composite resin which has lower elasticity modulus than enamel, contributing to the better dissipation of tensile stress in the cervical region.

These results are in agreement with other study (Reddy et al. 2012), which showed that any type of stress (tensile, compressive, or shearing), when sufficient in magnitude, can inflict damage on the tooth structure. Tooth structure when submitted to oblique loads suffers a flexure, producing tensile or compressive strain causing a disruption of the bonds between hydroxyapatite crystals, leading to the formation of cracks and eventual loss of enamel and underlying dentin, although the loads applied on the buccal surface have lower values, contributing to the reduction of the progression of the NCCLs (Grippo 1991; Lee and Eakle 1984). However, they obtained higher values of compressive stress on the vestibular of crestal bone, consequently increasing the odds of bone resorption (Machado et al. 2018). These results emphasize the importance of occlusal adjustment and restoration on NCCLs' treatment and on prevention of bone loss.

Another study (Madani and Ahmadian-Yazdi, 2005) investigating the relationship between premature contacts in centric relation and other occlusal discrepancies in teeth with and without NCCLs, found a statistically significant correlation between the prevalence of NCCLs and premature occlusal contacts. On the other hand, another study (Reyes, Hildebolt, Langenwalter and Miley, 2009) found the same distribution for NCCLs and premature contacts in centric relation at first premolars; however, no correlation was found between NCCLs and premature contacts. This difference may be explained by methodological applied in each study and the criterion that the data were analyzed.

In a similar study (Vandana et al. 2016), the authors reported that with decreasing periodontal support the location of the highest stress concentration tended to shift away from CEJ, which is supposed to be susceptible to abfraction, toward the apical dentin region. It means that abfractions are less likely to occur on a tooth with diminished periodontal support, and if does occur, must be more apically located (Grippo 1992). It is also in line with the findings of the present study, where the bone loss modified the stress field, but did not influence on the appearance of NCCLs.

On the other hand, Reyes et al. (Reyes, Hildebolt, Langenwalter and Miley, 2009) reported that is clear that abfraction lesions are associated with buccal attachment loss; however, the order of appearance between the two cannot be determined. It is possible that an abfraction lesion leads to buccal attachment loss, and it is also possible that buccal attachment loss makes the tooth surface more susceptible to abrasion or abfraction. This fact points out the etiology of NCCLs, which is largely discussed and has not yet been agreed on the literature.

CONCLUSION

Considering the methodological limitations of this study, it can be concluded that:

1. Oblique loading is the intensifying factor in the stress distribution pattern, influencing bone loss and NCCL progression.

2. The pattern of stress distribution in the bone was not influenced by the presence of NCCL.
3. The restoration did not influence the pattern of stress distribution in the bone.

REFERENCES

BERNHARDT, O., D. GESCH, C. SCHWAHN, F. MACK, et al. Epidemiological evaluation of the multifactorial aetiology of abfractions. J Oral Rehabil, Jan 2006, 33(1), 17-25. ISSN 0305-182X.

BORCIC, J., I. ANIC, I. SMOJVER, A. CATIC, et al. 3D finite element model and cervical lesion formation in normal occlusion and in malocclusion. J Oral Rehabil, Jul 2005, 32(7), 504-510. ISSN 0305-182X.

BORCIC, J., I. ANIC, M. M. UREK AND S. FERRERI The prevalence of non-carious cervical lesions in permanent dentition. J Oral Rehabil, Feb 2004, 31(2), 117-123. ISSN 0305-182X.

CARTER, D. R. AND W. C. HAYES The compressive behavior of bone as a two-phase porous structure. J Bone Joint Surg Am, Oct 1977, 59(7), 954-962. ISSN 0021-9355.

COBO, J., J. ARGUELLES, M. PUENTE AND M. VIJANDE Dentoalveolar stress from bodily tooth movement at different levels of bone loss. Am J Orthod Dentofacial Orthop, Sep 1996, 110(3), 256-262. ISSN 0889-5406.

COBO, J., A. SICILIA, J. ARGÜELLES, D. SUÁREZ, et al. Initial stress induced in periodontal tissue with diverse degrees of bone loss by an orthodontic force: Tridimensional analysis by means of the finite element method. Am J Orthod Dentofacial Orthop, 1993/11/01/ 1993, 104(5), 448-454. ISSN 0889-5406.

CORN, H. AND M. H. MARKS *Basic biological concepts associated with adult Orthodontics: Lea & Febiger*. Edtion ed. Philadelphia: Atlas of adult Orthodontics, 1989. ISBN 0812110234.

DEJAK, B. AND A. MLOTKOWSKI Finite element analysis of strength and adhesion of cast posts compared to glass fiber-reinforced composite resin posts in anterior teeth. J Prosthet Dent, Feb 2011, 105(2), 115-126. ISSN 1097-6841.

GERAMY, A. Alveolar bone resorption and the center of resistance modification (3-D analysis by means of the finite element method). Am J Orthod Dentofacial Orthop, Apr 2000, 117(4), 399-405. ISSN 0889-5406.

GRIPPO, J. O. Abfractions: A New Classification of Hard Tissue Lesions of Teeth. J Esthet Dent, 1991, 3(1), 14-19. ISSN 1040-1466.

GRIPPO, J. O. Noncarious cervical lesions: the decision to ignore or restore. J Esthet Dent, 1992, 4 Suppl, 55-64. ISSN 1040-1466.

GRIPPO, J. O., M. SIMRING AND T. A. COLEMAN Abfraction, abrasion, biocorrosion, and the enigma of noncarious cervical lesions: a 20-year perspective. J Esthet Restor Dent, Feb 2012, 24(1), 10-23. ISSN 1708-8240.

ICHIM, I., P. R. SCHMIDLIN, J. A. KIESER AND M. V. SWAIN Mechanical evaluation of cervical glass-ionomer restorations: 3D finite element study. J Dent, Jan 2007, 35(1), 28-35. ISSN 0300-5712.

KIM, S. Y., K. W. LEE, S. R. SEONG, M. A. LEE, et al. Two-year clinical effectiveness of adhesives and retention form on resin composite restorations of non-carious cervical lesions. Oper Dent, Sep-Oct 2009, 34(5), 507-515. ISSN 0361-7734.

LEE, W. C. AND W. S. EAKLE Possible role of tensile stress in the etiology of cervical erosive lesions of teeth. J Prosthet Dent, Sep 1984, 52(3), 374-380. ISSN 0022-3913.

MACHADO, A. C., A. J. F. N. NETO, C. D. D. S. JÚNIOR, A. L. R. VILELA, et al. Influência do desequilíbrio oclusal na origem de lesão cervical não cariosa e recessão gengival: análise por elementos finitos. Revista Odontológica do Brasil Central, 2018, 27(83), 204-2010. ISSN 0107-7914.

MADANI, A. O. AND A. AHMADIAN-YAZDI An investigation into the relationship between noncarious cervical lesions and premature contacts. Cranio, Jan 2005, 23(1), 10-15. ISSN 0886-9634.

MICHAEL, J. A., G. C. TOWNSEND, L. F. GREENWOOD AND J. A. KAIDONIS Abfraction: separating fact from fiction. Aust Dent J, Mar 2009, 54(1), 2-8. ISSN 0045-0421.

MIURA, J., Y. MAEDA, H. NAKAI AND M. ZAKO Multiscale analysis of stress distribution in teeth under applied forces. Dent Mater, Jan 2009, 25(1), 67-73. ISSN 1879-0097.

POIATE, I. A., A. B. VASCONCELLOS, E. POIATE JUNIOR AND K. R. DIAS Stress distribution in the cervical region of an upper central incisor in a 3D finite element model. Braz Oral Res, Apr-Jun 2009, 23(2), 161-168. ISSN 1807-3107.

REDDY, S., D. KSHITISH, S. MANNEM, B. RAO, et al. Cervical stress due to normal occlusal loads is a cause for abfraction? - A finite element model study. J Orofac Sci, 01/01 2012, 4, 120. ISSN 0975-8844.

REES, J. S. A review of the biomechanics of abfraction. Eur J Prosthodont Restor Dent, Dec 2000, 8(4), 139-144. ISSN 0965-7452.

REES, J. S. The effect of variation in occlusal loading on the development of abfraction lesions: a finite element study. J Oral Rehabil, Feb 2002, 29(2), 188-193. ISSN 0305-182X.

REYES, E., C. HILDEBOLT, E. LANGENWALTER AND D. MILEY Abfractions and attachment loss in teeth with premature contacts in centric relation: clinical observations. J Periodontol, Dec 2009, 80(12), 1955-1962. ISSN 1943-3670.

RUBIN, C., N. KRISHNAMURTHY, E. CAPILOUTO AND H. YI Stress analysis of the human tooth using a three-dimensional finite element model. J Dent Res, Feb 1983, 62(2), 82-86. ISSN 0022-0345.

SHINYA, A., D. YOKOYAMA, L. V. LASSILA, A. SHINYA, et al. Three-dimensional finite element analysis of metal and FRC adhesive fixed dental prostheses. J Adhes Dent, Oct 2008, 10(5), 365-371. ISSN 1461-5185.

SOARES, P. V., MACHADO A. C., ZEOLA L. F., SOUZA P. G., et al. Loading and composite restoration assessment of various non-carious cervical lesions morphologies - 3D finite element analysis. Aust Dent J, Sep 2015, 60(3), 309-316. ISSN 1834-7819.

SOARES, P. V., P. C. SANTOS-FILHO, C. J. SOARES, V. L. FARIA, et al. Non-carious cervical lesions: influence of morphology and load type on biomechanical behaviour of maxillary incisors. Aust Dent J, Sep 2013, 58(3), 306-314. ISSN 1834-7819.

SOARES, P. V., SOUZA L. V., VERÍSSIMO C., ZEOLA L. F., et al. Effect of root morphology on biomechanical behaviour of premolars associated with abfraction lesions and different loading types. J Oral Rehabil, 2014/02/01 2014, 41(2), 108-114. ISSN 0305-128X.

TEIXEIRA, D. N. R., R. Z. THOMAS, P. V. SOARES, M. S. CUNE, et al. Prevalence of noncarious cervical lesions among adults: A systematic review. J Dent, Apr 2020, 95, 103285. ISSN 0300-5712.

TEIXEIRA, D. N. R., L. F. ZEOLA, A. C. MACHADO, R. R. GOMES, et al. Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: A cross-sectional study. J Dent, Sep 2018, 76, 93-97. ISSN 0300-5712.

VANDANA, K. L., M. DEEPTI, M. SHAIMAA, K. NAVEEN, et al. A finite element study to determine the occurrence of abfraction and displacement due to various occlusal forces and with different alveolar bone height. J Indian Soc Periodontol, Jan-Feb 2016, 20(1), 12-16. ISSN 0972-124X.

VASUDEVA, G. AND P. BOGRA The effect of occlusal restoration and loading on the development of abfraction lesions: A finite element study. J Conserv Dent, Jul 2008, 11(3), 117-120. ISSN 0974-5203.

WEINSTEIN, A. M., J. J. KLAWITTER AND S. D. COOK Implant-bone interface characteristics of bioglass dental implants. J Biomed Mater Res, Jan 1980, 14(1), 23-29. ISSN 0021-9304.

WOOD, I., Z. JAWAD, C. PAISLEY AND P. BRUNTON Non-carious cervical tooth surface loss: a literature review. J Dent, Oct 2008, 36(10), 759-766. ISSN 0300-5712.

ZEOLA, L., F. PEREIRA, A. GALVÃO, T. MONTES, et al. Influence of non carious cervical lesions depth, loading point application and restoration on stress distribution pattern in lower premolars: A 2D finite element analysis. Bioscience, 03/01 2015, 31, 648-656. ISSN 1981-3163.

Table 1. Mechanical properties used to perform orthotropic and isotropic structures.

Structures	Orthotropic Structures (Miura, Maeda, Nakai and Zako 2009)		
		Elastic Modulus (MPa)	
	LONGITUDINAL	TRANSVERSAL	Z
Enamel	73720	63270	63270
Dentin	17070	5610	5610
		Shear coefficient (MPa)	
Enamel	20890	24070	20890
Dentin	1700	6000	1700
		Poisson Ratio (v)	
Enamel	0.23	0.45	0.23
Dentin	0.30	0.33	0.30
Structures		**Isotropic Structures**	
		Elastic Modulus (MPa)	**Poisson Ratio (v)**
Pulp (Rubin, Krishnamurthy, Capilouto and Yi 1983)		2.07	0.45
Periodontal Ligament (Miura, Maeda, Nakai and Zako 2009)		68.9	0.45
Cortical Bone (Carter and Hayes 1977)		13700	0.30
Medullary Bone (Carter and Hayes 1977)		1370	0.30
Hybrid Composite Resin (Shinya, Yokoyama, Lassila, Shinya and Vallittu 2008)		22000	0.27

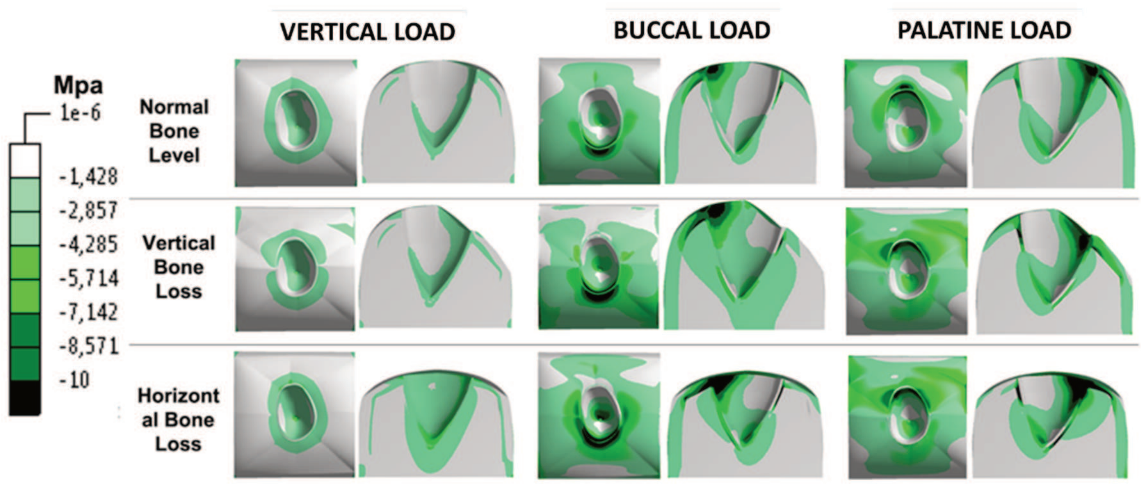


Figure 1. Minimum Principal Stress of the crestal bone.

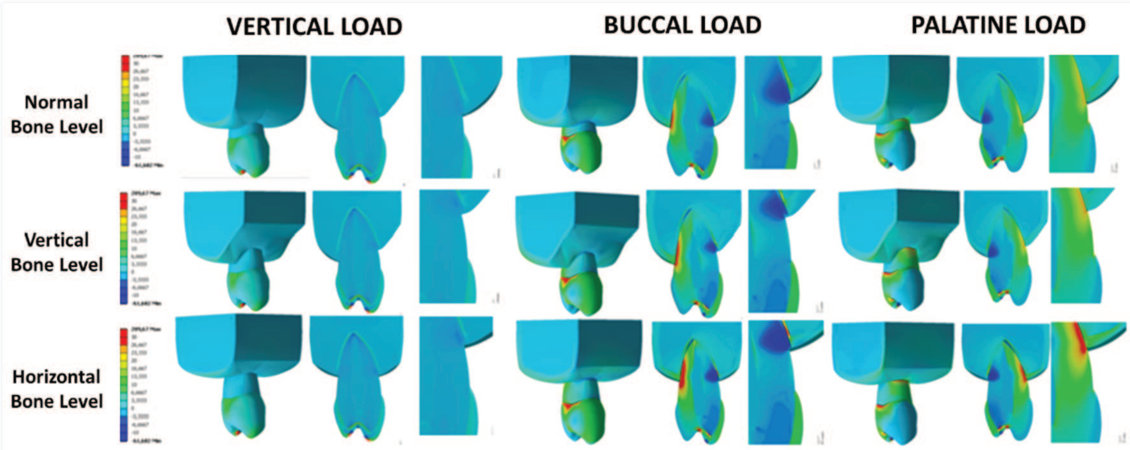


Figure 2. Sound teeth models with different types of loads and bone attachment.

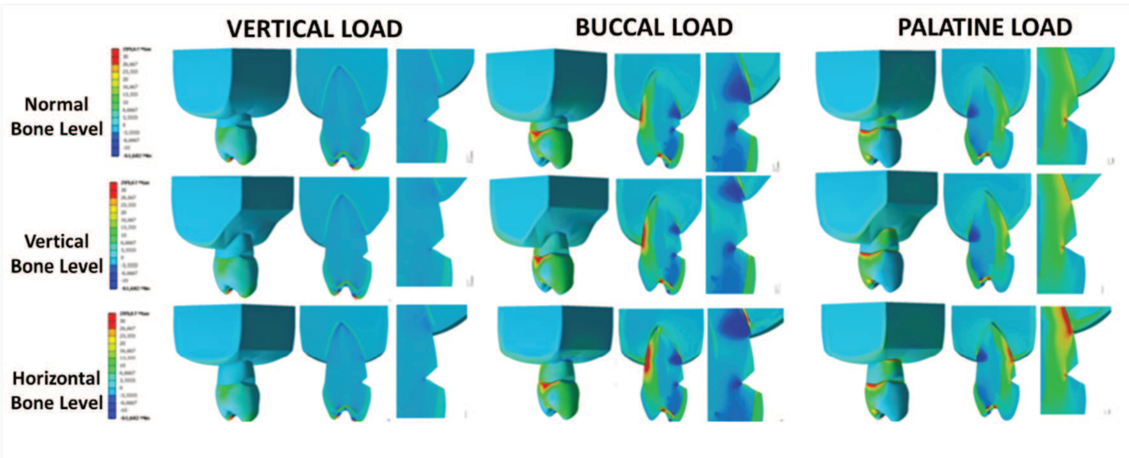


Figure 3. Models of teeth with NCCL with different types of loads and bone attachment.

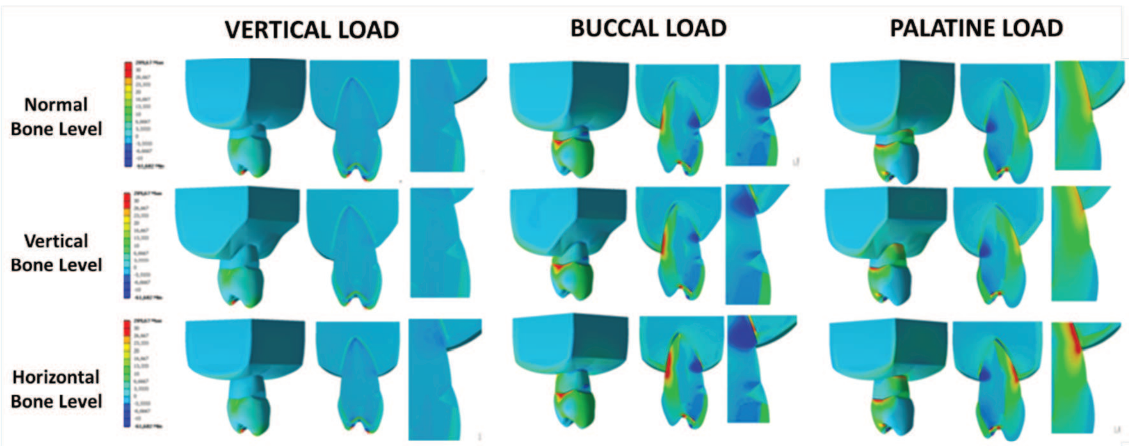


Figure 4. Restored teeth models with different types of loads and bone attachment.

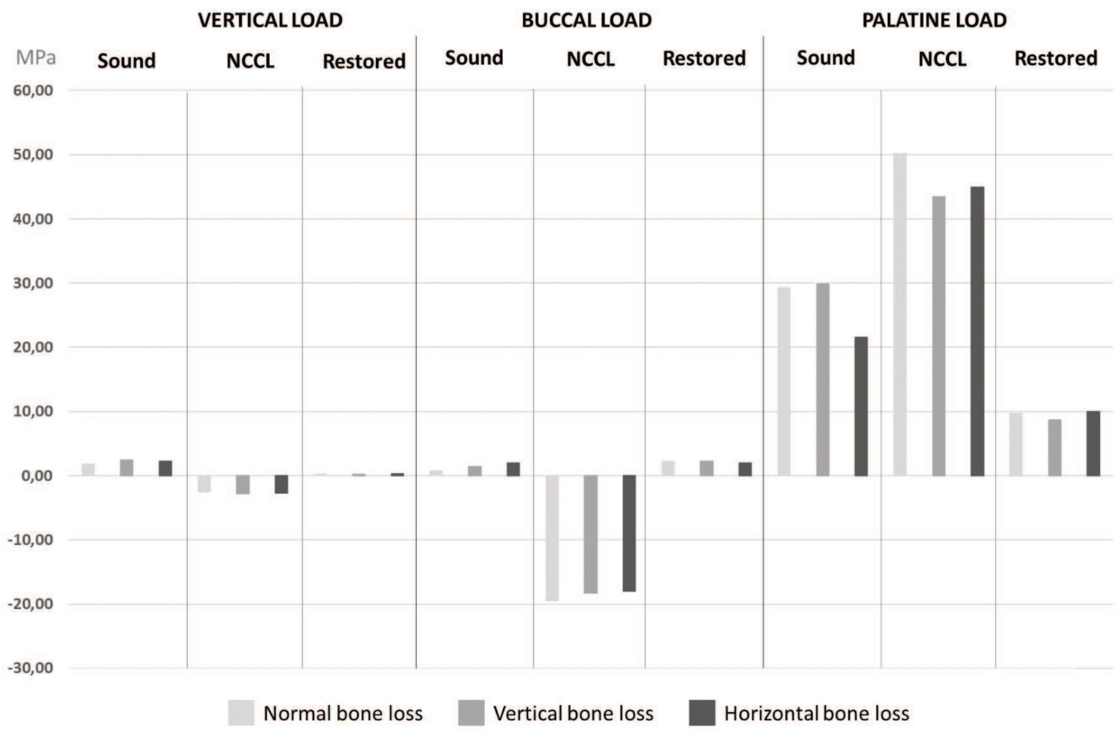


Figure 5. Stress values (MPa) obtained on one node of the mesh on the cervical region by maximum principal stress.

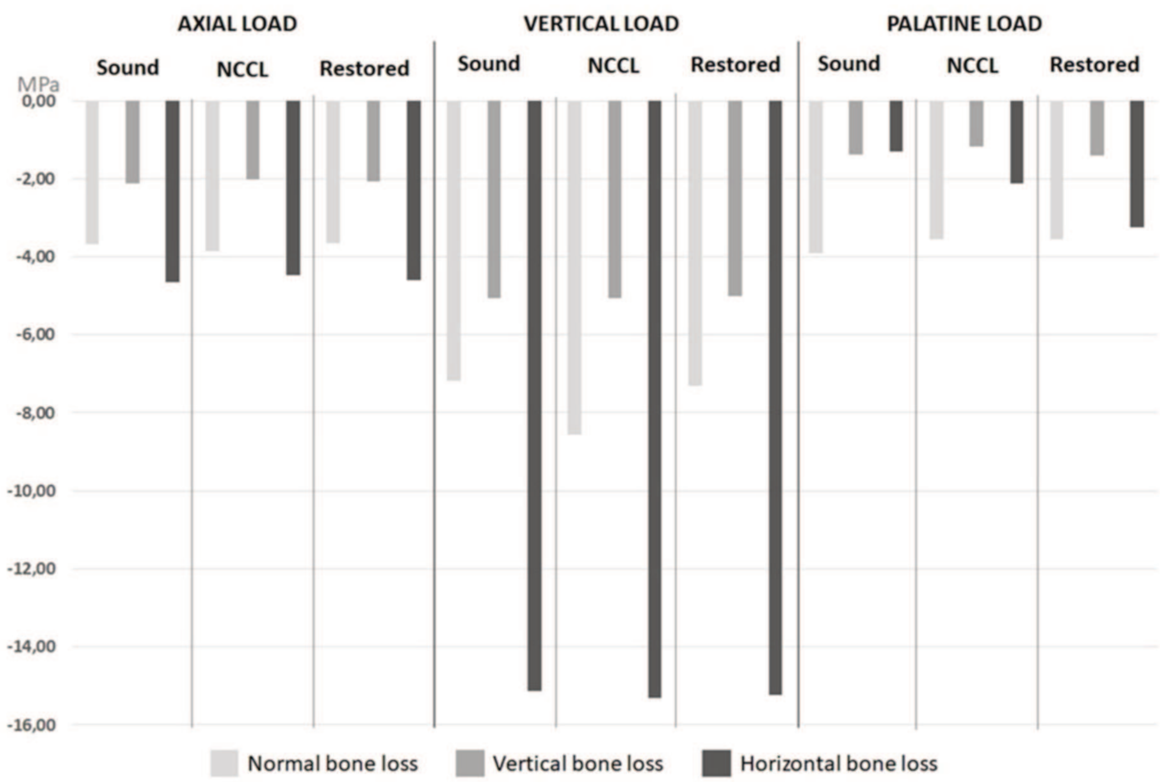


Figure 6. Compression stress values (MPa) evaluated in one node on the crestal bone by minimum principal stress.

3 CONCLUSÃO

Dentro das limitações metodológicas impostas pelo delineamento deste estudo, que envolveu duas revisões sistemáticas e um estudo laboratorial, pode-se concluir que:

- A prevalência mundial estimada de lesões cervicais não cariosas é de 46,7%, sendo mais prevalente em populações mais velhas;
- Idade, vigor na escovação dentária, presença de contatos prematuros/interferências, facetas de desgaste e hábitos parafuncionais foram considerados os fatores de risco mais significativos associados as LCNCs, apesar da heterogeneidade dos estudos avaliados;
- O padrão de distribuição de tensão no osso alveolar não é influenciado pela presença de lesões cervicais não cariosas, independentemente das cargas oclusais aplicadas.

REFERÊNCIAS

Aw TC, Lepe X, Johnson GH, Mancl L. Characteristics of noncarious cervical lesions: a clinical investigation. J Am Dent Assoc 2002;133:725–33.

Barron RP, Carmichael RP, Marcon MA, Sàndor GKB. Dental erosion in gastroesophageal reflux disease. J Can Dent Assoc 2003;69:84–9.

Bartlett D. Etiology and prevention of acid erosion. Compend Contin Educ Dent 2009;30:616–20.

Cobo J, Argüelles J, Puente M, Vijande M. Dentoalveolar stress from bodity tooth movement at different levels of bone loss. Am J Orthod Dentofac Orthop 1996;110:256–62. doi:10.1016/S0889-5406(96)80008-4.

Cobo J, Sicilia A, Argüelles J, Suárez D, Vijande M. Initial stress induced in periodontal tissue with diverse degrees of bone loss by an orthodontic force: Tridimensional analysis by means of the finite element method. Am J Orthod Dentofac Orthop 1993;104:448–54. doi:10.1016/0889-5406(93)70071-U.

Dawes C. What is the critical pH and why does a tooth dissolve in acid? J Can Dent Assoc 2003;69:722–4.

Dejak B, Młotkowski A. Finite element analysis of strength and adhesion of cast posts compared to glass fiber-reinforced composite resin posts in anterior teeth. J Prosthet Dent 2011;105:115–26. doi:10.1016/S0022-3913(11)60011-5.

Eisenburger M, Shellis RP, Addy M. Comparative Study of Wear of Enamel Induced by Alternating and Simultaneous Combinations of Abrasion and Erosion in vitro. Caries Res 2003;37:450–5. doi:10.1159/000073399.

Geramy A. Alveolar bone resorption and the center of resistance modification (3-D analysis by means of the finite element method). Am J Orthod Dentofac Orthop 2000;117:399–405. doi:10.1016/S0889-5406(00)70159-4.

Grippo JO, Oh DS. A classification of the mechanisms producing pathological tissue changes. J Med Eng Technol 2013;37:259–63. doi:10.3109/03091902.2013.789565.

Grippo JO, Simring M, Coleman TA. Abfraction, abrasion, biocorrosion, and the enigma of noncarious cervical lesions: A 20-year perspective. J Esthet Restor Dent 2012;24:10–23. doi:10.1111/j.1708-8240.2011.00487.x.

Hawkins N, Richard PS, Granley HM, Stein DM. The Impact of Exposure to the Thin-Ideal

Media Image on Women. Eat Disord 2004;12:35–50. doi:10.1080/10640260490267751.

Ichim I, Schmidlin PR, Kieser JA, Swain M V. Mechanical evaluation of cervical glass-ionomer restorations: 3D finite element study. J Dent 2007;35:28–35. doi:10.1016/j.jdent.2006.04.003.

Litonjua LA, Andreana S, Bush PJ, Tobias TS, Cohen RE. Wedged cervical lesions produced by toothbrushing. Am J Dent 2004;17:237–40.

Michael JA, Townsend GC, Greenwood LF, Kaidonis JA. Abfraction: separating fact from fiction. Aust Dent J 2009;54:2–8. doi:10.1111/j.1834-7819.2008.01080.x.

Orchardson R, Gangarosa LP, Holland GR, Pashley DH, Trowbridge HO, Ashley FP, et al. Dentine hypersensitivity—Into the 21st century. Arch Oral Biol 1994;39:S113–9. doi:10.1016/0003-9969(94)90197-X.

Pashley DH. How can sensitive dentine become hypersensitive and can it be reversed? J Dent 2013;41:S49–55. doi:10.1016/S0300-5712(13)70006-X.

Rees JS. A review of the biomechanics of abfraction. Eur J Prosthodont Restor Dent 2000;8:139–44.

Sangnes G, Gjermo P. Prevalence of oral soft and hard tissue lesions related to mechanical toothcleansing procedures. Community Dent Oral Epidemiol 1976;4:77–83.

Soares P V., Souza L V., Veríssimo C, Zeola LF, Pereira AG, Santos-Filho PCF, et al. Effect of root morphology on biomechanical behaviour of premolars associated with abfraction lesions and different loading types. J Oral Rehabil 2014;41:108–14. doi:10.1111/joor.12113.

Teixeira DNR, Zeola LF, Machado AC, Gomes RR, Souza PG, Mendes DC, et al. Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: A cross-sectional study. J Dent 2018;76:93–7. doi:10.1016/j.jdent.2018.06.017.

Wood I, Jawad Z, Paisley C, Brunton P. Non-carious cervical tooth surface loss: A literature review. J Dent 2008;36:759–66. doi:10.1016/j.jdent.2008.06.004.