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Relationship between noncarious cervical lesions, cervical dentin hypersensitivity, gingival recession, and associated risk factors: A cross-sectional study

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A R T I C L E I N F O

Keywords:
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A B S T R A C T

Objectives: The aim of this study was to evaluate the risk factors associated with noncarious cervical lesions (NCCLs), cervical dentin hypersensitivity (CDH), and gingival recession (GR), besides the relationship among these conditions in a specific Brazilian sample population.
Methods: 185 patients who attended the "Ambulatory Program for Rehabilitation of Patients with Noncarious Cervical Lesions and Cervical Dentin Hypersensitivity" were evaluated, and 5180 teeth were analyzed. The subjects filled out a form and a calibrated examiner performed the clinical exams to determine the presence of NCCLs, CDH, and GR. NCCLs were classified according to their morphology and depth, CDH levels were evaluated according to air stimuli response, and GRs were categorized according to Miller's classification. The association of the risk factors with NCCLs, CDH, and GR was determined with the Mann-Whitney U test and multiple linear regression. For the correlations, the Spearman test was used with a 95%-confidence level.
Results: The NCCLs, CDH, and GR distributions within the study were 88.1%, 89.1%, and 59.4%, respectively. Maxillary premolars were the most affected by all three conditions. A positive correlation was found between age, NCCLs, and GR; between NCCLs and CDH; CDH and GR; GR and NCCLs. Age, gender, oral hygiene, gastroesophageal diseases, and occlusal trauma were significantly associated with the presence of all three conditions.
Conclusions: The NCCLs and GR distributions increased with age; NCCLs, CDH, and GR had positive correlation; the lesions' depth and morphology contributed to high levels of sensitivity and severity of recessions; age, gender, gastric disease, and occlusal trauma were relevant factors for the occurrence of NCCLs, CDH, and GR.
Clinical significance: The increasing distribution of NCCLs, CDH, and GR is closely associated with people's lifestyles. Thus, it is important for the clinicians to recognize the etiological factors and their most relevant associations to prevent and control such alterations, in order to improve the population's quality of life.

1. Introduction

The tooth structure loss at the cementum-enamel junction that is not associated to the presence of caries has been identified as noncarious cervical lesions (NCCLs) [1], with 5%–85% prevalence rate variation [2]. Current studies suggest that the formation and/or progression of NCCLs have multifactorial etiology [3,4], i.e. the association between factors such as erosion (chemical or electrochemical dental tissue degradation), friction, attrition (endogenous mechanical wear), and abrasion (exogenous mechanical wear) (4–6), besides occlusal stress [7].

However, the different lesion morphologies are usually related to

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the prevalence of a specific etiological factors in the cervical area [5,8], resulting in wedge-shaped or concave lesions [9].

The increased prevalence of cervical tooth wear with aging implies that NCCLs are probably a result of a time-dependent progression process [1]. In addition, considering the combined effects of all potential etiological factors, the NCCLs presence may contribute to dentin exposure and biofilm accumulation in the cervical site. As a consequence, NCCLs has been associated with other conditions, such as cervical dentin hypersensitivity (CDH) [10] and gingival recession (GR) [11] affecting the same tooth.

Still, epidemiological studies that correlate the presence of NCCLs, CDH, GR, and risk factors are not common, due to the difficulty in obtaining and comparing data from different populations [12]. Even within the same population, the differences in clinical characteristics and risk factors involving these conditions have to be further explored.

Therefore, the aim of this study was to evaluate the risk factors associated with NCCLs, CDH, and GR, apart from the relationship amongst these conditions in a specific Brazilian sample population.

2. Materials and methods

2.1. Subjects

The research protocol for the present study was first submitted to the Ethical Committee of the Federal University of Uberlândia (#1.373.058). After approval, the details of the investigation and procedures were explained to each subject. The population included in the current study were patients from the "Ambulatory Program for the Rehabilitation of Patients with Noncarious Cervical Lesions and Cervical Dentin Hypersensitivity", located at the Dental Hospital of the Federal University of Uberlândia, Brazil. The investigation occurred from August 2013 to August 2016. To be considered for this study, the subjects should be more than 18 years old and present at least one of the three alterations (NCCLs, CDH and/or GR), isolatedly or combined. Patients with any missing teeth (except for third molars), diseases requiring analgesic drugs or anything that could mask the sensitivity symptoms were excluded. In addition, teeth with or under endodontic treatment (only for CDH), under orthodontic treatment, with marginal restorations that could interfere in the evaluation, with marginal leakage, pulpitis, dental caries, and fractures were also excluded.

2.2. Assessments

The form and clinical examination data sheets were designed for data collection and included about the following queries: participant's name, place of birth, medical history, hygiene quality evaluated by the examiner, and tooth-brushing type according to the patient's self-perception. Then, a sheet of paper was delivered to each patient so that they could fill out with a description of what their eating habits would be for one week. The diet would be considered acidic when the number of acidic drinks and/or food incidence was greater than two. Participants were also questioned about the presence of parafunctional habits and gastroesophageal diseases. Patients that were previously diagnosed with gastroesophageal diseases were only accepted if under controlled stage or when the disease was excluded by the specialist.

A clinical examination was individually performed. Occlusal trauma was accessed with the use of carbon tape (*AccuFilm II* - Edgewood, NY, USA), to identify patients' premature contacts in centric relation, in all movements.

NCCLs were classified according to their morphology type, in concave [1] or wedge-shaped [2]. Then, the depth of each lesion was evaluated through NCCL impression with polyvinyl siloxane (PVS) elastomeric material. The impressions were measured by means of a digital caliper and the lesions were classified as shallow (00.9 mm), medium (1–1.9 mm), or deep (greater than 2 mm).

The subjects who reported sensitivity were clinically evaluated for confirmation of CDH presence. An evaporative stimulus (controlled air blast) generated by an air-water syringe was used to determine the tooth sensitivity level. The air jet was perpendicularly directed to the cervical buccal surface of the hypersensitive tooth for two seconds at approximately 1 cm-distance. The adjacent teeth were protected with a polyester strip to avoid false-positive results. The operator requested the participants to rate their pain according to a 10-point visual analog scale (VAS) and the value was recorded. The recorded values were distributed according to their level: 0 – no pain; 2 – mild pain [1–4]; 3 – moderate pain [5–7]; 4 – severe pain [8–10].

GR presence was also checked and classified according to Miller [13] in I, II, III or IV Class, considering the amount of keratinized tissue, the mucogingival junction location related to the recession and the presence or absence of interproximal bone loss.

2.3. Data analysis and statistical tests

Data collected at the anamnesis questionnaire and clinical examinations were classified per patients and per number of teeth. As data did not present normal distribution, the bivariate analysis of dependent variables (NCCL, HD, GR) and the risk factor analysis were performed by Mann-Whitney U test. To verify the study hypothesis, all independent variables that showed association (p-value < .25) were subjected to a multivariate (multiple linear regression) model, following a backward technique. The Spearman correlation test was used to analyze the correlation between the morphology and the depth of NCCLs with CDH level. All analyses were performed with 95%-significance level.

3. Results

3.1. Age

185 individuals (age19 - 7, mean: 41.9 years old) were included in the present study. The male:female ratio was 0.68:1. After clinical examination, 163 out of the 185 subjects were diagnosed with NCCL, 165 with CDH, and 110 with GR, resulting in a distribution of 88.1%, 891%, and 59.4%, respectively. From the 163 subjects with NCCLs, 161 (98.7%) also presented CDH, and 106 (57.2%) presented all three conditions, concomitantly. 5180 teeth were examined. 1308 (25.2%) were diagnosed with NCCLs, 1613 (31.1%) with CDH, and 1334 (25.7%) with GR. Within the teeth with NCCLs, 810 (61.9%) also presented CDH, and 479 (36.6%) exhibited all three conditions, concomitantly.

The distribution of the conditions within different age groups is shown in Fig. 1. NCCLs, CDH, and GR showed similar distribution increase, the higher the age. A larger number of subjects with NCCLs, CDH or GR was found in the > 50 age group, whereas concentration smaller number was found within the 19–30 age group. The trend of NCCLs curve presented faster increase than the CDH or the GR curves

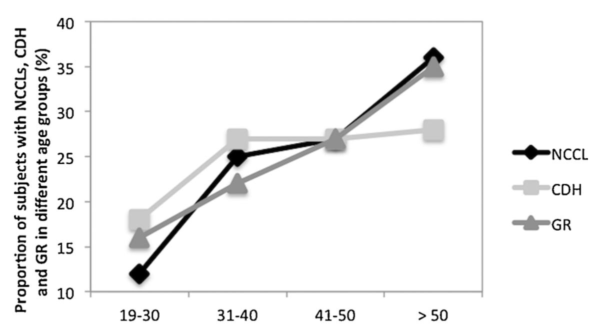

Fig. 1. Subjects distribution per age with isolated incidence of NCCLs, CDH and GR.

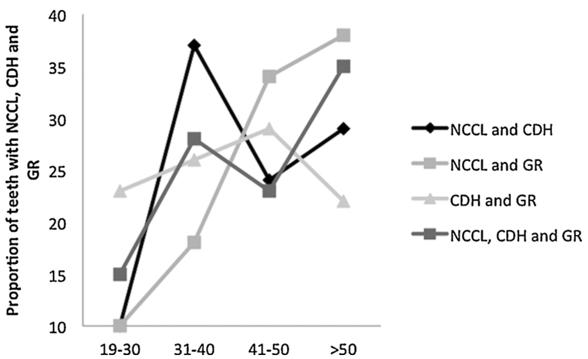

Fig. 2. Subject distribution per age with combined incidence of NCCL + CDH, NCCL + GR, GR + CDH, and NCCL + CDH + GR.

when age was concerned.

The results also showed that in the 19–30 age group, the association of CDH and GR was the most common condition (Fig. 2). On the other hand, in the 31–40 group, the association of NCCLs and CDH were more frequent. In the 41–50 age group, there was an incidence confluence of all three conditions. In the group of subjects older than 50, CDH seemed to decrease and the NCCLs and GR association turn out to be more frequent (Fig. 2).

3.2. Tooth type

Maxillary teeth were more affected than mandible teeth, considering all three conditions. The presence of NCCLs, CDH, and GR per tooth type showed that premolars were the most commonly affected teeth, followed by the first molars and the canines. The second molars were the least affected.

3.3. Correlations

A weak or moderate correlation between the presence of NCCLs and CDH ($p = 0.008$); NCCLs and GR ($p < 0.001$); CDH and GR ($p < 0.001$) were found, with correlation coefficients of 0.19, 0.49 and 0.26, respectively.

The correlation between NCCLs depth and CDH level was also positive ($p < 0.001$), with a 0.47 correlation coefficient. For the morphology, a positive correlation ($p = 0.006$) of wedge-shaped lesions and CDH levels was verified, though its strength was low ($r = 0.07$).

Similarly, there was a moderate correlation ($p < 0.001$) between the level of sensitivity and the GRs classification ($r = 0.47$). The same result was found regarding GRs classification compared to the depth of the lesions ($p < 0.001$), with a low strength coefficient of 0.32.

3.4. Risk factors

The possible risk factors of NCCLs, CDH and GR are shown in Table 1. All the independent variables that demonstrated an association with a p-value < 0.25 in this bivariate analysis were submitted to the multivariate model. The linear regression in Table 2 shows that the most important risk factors for NCCL were age, gender, and occlusal trauma; for CDH, gender and gastric diseases; for GR, age, and occlusal trauma. Brushing, acid diet and parafunctional habits did not present significant statistically differences for any of the alterations to be regarded as relevant risk factors.

4. Discussion

In the present study, a standardized questionnaire was used to assess the risk factors associated with NCCLs, CDH and GR in a specific population of patients. The distribution of NCCLs, CDH, and GR found was 88.1%, 89.1%, and 59.4%, respectively. These values are higher than the range reported in previous studies [14,15], and it may be due to the fact that the examined subjects were patients of a specific clinic for the treatment of these specific conditions.

This study's findings corroborate with the ones from previous studies, which reported that the prevalence of NCCLs and GR increases with age [1,12,16–18], most probably because older people are exposed to the etiological factors for longer periods than the youngsters. On the other hand, CDH levels seem to decrease with age, and it could be due to the continued dentin deposition and subsequent pulp atrophy during lifetime [19].

The most NCCLs and CDH susceptible teeth [1,2,12,17,20] were the maxillary premolars. These teeth show less crown volume, a considerably thinner buccal bone plate, and receive excessive lateral load during mandible excursive movements. These may lead to higher flexion of the tooth to the buccal direction, amplifying deformations in the cervical region [21,22], which could explain the higher NCCLs prevalence and distribution.

In this regard, some studies have shown that eccentric occlusal loads are associated with the presence of NCCLs [23–26], and it corroborates with the findings of this study. However, data is still insufficient and/or inconclusive, as most studies that confirm such association have no robust evidence base. This has been addressed by two systematic reviews, which showed no evidence for this correlation [22,27]. In contrast, the main association that most studies have made between occlusion and NCCLs is through the presence of occlusal wear facets [28–31], and these were often made only by a single, non-blinded examiner, leading to possible bias results, which reduces their reliability [27]. Thus, stronger evidence-based and standardized studies should be carried out for more conclusive results.

A study in China [20] showed that the NCCLs presence was strongly associated with CDH. Nonetheless, the relationship between NCCLs' depth and CDH levels is still scarce in literature. In this study, a positive correlation was found for this association and also between wedge-shaped lesions and CDH levels. These findings could be attributed to the proximity of the lesion bottom wall with the pulp (in deeper lesions) and by the amount of exposed dentinal tubules, which increases the painful reaction [32]. Likewise, the positive correlation between severe GRs and high levels of CDH are in line with the theory that root exposition makes the tissue more vulnerable to the influence of CDH risk factors [1].

The difference in the NCCLs distribution between men and women could be explained by the greater masticatory strength (greater occlusal loads generate higher stress concentrations), which makes the dental structure more susceptible to other risk factors [4]. Interestingly, women showed greater chances of presenting CDH, which may be associated with healthy oral habits or with the frequent acidic foods intake and the presence of lower pain threshold than that of men [33,34]. There was no statistically difference regarding the presence of GRs as far as genders were concerned.

Regarding specific risk factors, according to some authors, the biofilm acidity, which is considered a triggering aspect for GR, acts as an endogenous biocorrosive factor [3] and may also contribute to NCCLs progression. However, this differs from the findings of this study; therefore, this study does not present evidence to conclusively acknowledge the association between the biofilm and NCCLs.

In this context, the influence of toothbrushing, which is considered an abrasion event, remains controversial on the influence of NCCLs progression. According to some authors, under normal and adequate use, brushing with toothpaste would only cause minimal dentin wear throughout life [35]. Other studies state that the high prevalence of lesions on the buccal aspect of the teeth automatically imply the influence of toothbrushing in NCCLs formation [36], which goes in line with a Chinese study, in which it was found that the power of toothbrushing was a predictor of NCCLs presence [37]. On the other hand, a recent systematic review [38] suggested that the data to support the

Table 1
Bivariate analysis (Mann Whitney) between NCCL, CDH and GR and risk factors in overall sample (n = 185).

Variables		NCCL			CDH			GR		
		Mean	SE	p value	Mean	SE	p value	Mean	SE	p value
Gender	Female	6.27	0.47	0.026*	9.84	0.67	0.004*	6.67	0.55	0.521
	Male	8.24	0.68		7.08	0.74		8	0.92	
Oral hygiene	Without visible plaque	6.15	0.49	0.002*	8.12	0.62	0.135	6.32	0.61	0.013*
	With visible plaque	8.59	0.64		9.7	0.86		8.67	0.82	
Brushing with excessive force	No	6.55	0.59	0.337	8.32	0.75	0.586	6.95	0.79	0.497
	Yes	7.43	0.54		9	0.68		7.39	0.64	
Acid diet	No	6.96	1.22	0.746	8.16	1.41	0.594	7.68	1.48	0.788
	Yes	7.09	0.42		8.81	0.54		7.14	0.53	
Gastric diseases	No	6.81	0.48	0.210	7.97	0.56	0.032*	6.64	0.552	0.116
	Yes	7.76	0.72		10.74	1.08		8.76	1.07	
Parafunctional habits	No	7.14	0.57	0.606	7.74	0.73	0.104	6.96	0.79	0.652
	Yes	7.02	0.55		9.43	0.69		7.39	0.64	
Premature contacts	No	4.61	1.10	0.008*	6.65	1.29	0.110	3.91	0.94	0.014*
	Yes	7.42	0.42		9.01	0.55		7.68	0.54	

SE = Standard Error.
* = significant statistic difference.

association between toothbrushing and NCCL/GR remain largely inconclusive and that long-term projects need to be carried out to determine, with confidence, whether this factor consists of predisposition, or is just associated with the mentioned alterations. Other reports also showed that there are patients with NCCLs in non-brushing populations [39,40], which could indicate that toothbrushing is not an NCCLs triggering element, but rather an intensifying or accelerating influence in the process. Yet, none of these studies have shown a clear or standardized evaluation method. Thus, since the methods are limited and the results found in this population were not sufficient for conclusion, more studies are essential, so that the role of toothbrushing in the progression of lesions may be duly clarified. Similarly, the association and clinical relevance of GR development after brushing remains uncertain and unproven [38,41,42].

Previous literature showed that the consumption of citrus fruits and juices, soft drinks, alcohol, and vitamin C tablets is recognized as a source of dental structure aggression, which is associated with the presence of NCCLs [43]. Similarly, an earlier European study with a large sample of 3187 subjects used descriptors to measure how high the patient's acid consumption was [44] and found that fresh fruit and juice intake was positively associated with tooth wear. However, no statistically significant difference was found between the acid diet and the presence of any of the alterations in this study, even though the authors truly believe that it plays a very important role on the development of NCCLs and CDH. In another study [45], no significant association between NCCLs and the consumption of acidic fruits and soft drinks was found, and such discrepant results may be explained by the current eating habits within the population, in which food of acidic nature is very common, despite subjects sample sizes and the differences between the studied populations regarding diet, oral hygiene habits, and

Table 2
Multivariate analysis (linear regression) of factors associated with NCCL, CDH and GR in overall sample (n = 185).

NCCL		Estimate (B)	95%CI	p
Age		0.131	0.074– 0.189	< 0.001*
Gender	Female	Reference		
	Male	1.669	0.170– 3.167	0.029*
Premature contacts	No	Reference		
	Yes	2.999	0.774– 5.223	0.009*

CDH		Estimate (B)	95%CI	p
Gender	Female	Reference		
	Male	−2.624 to −4.621	−4.621 to −.626	0.010*
Gastric diseases	No	Reference		
	Yes	2.606	0.– 4.815	0.021*

GR		Estimate (B)	95%CI	p
Age		0.116	0.043–0.190	0.002*
Premature contacts	No	Reference		
	Yes	3.956	1.072– 6.840	0.007*

* = significant statistic difference.

socio-economic status. Furthermore, there are no literature-standardized methods to properly evaluate an acid diet, which configures another limitation in this study.

The role of gastroesophageal diseases in the progression of teeth surface loss is already proven. Studies have shown that repeated or prolonged exposure of the teeth to gastric acids leads to the selective dissolution of dental surface's specific components, causing structure loss and dentin hypersensitivity. The severity of dental wear and chemical degradation of structures due to gastroesophageal reflux, for example, is correlated to the disease's duration and frequency, pH, acid type, salivary quality and quantity, and buffer effect capacity [46,47].

Regarding parafunctional habits, occlusal parafunction is more likely to favor the dental substance loss in the cervical region than physiological processes [3,4], as the force magnitudes during bruxism are much greater than the loads of normal functional activity [48]. The opposite result found in the present study may be associated with the applied methodology, which used a questionnaire and clinical examination to detect any occlusal wear [23] rather than a laboratorial strength trial.

It has been suggested that the association of the risk factors should be considered, as the events seldom occur alone [3]. Also, an effective approach to the prevention and treatment of NCCLs, CDH, and GR should encompass risk factors management, since alterations may be associated, facilitating its progression. Still, additional information and future studies in this area may allow better comprehension and management of findings.

Lastly, this study confirms, within its limitations, that NCCLs and GR distributions increased with age; NCCLs, CDH, and GR had positive correlations; the lesions' depth and morphology contributed to different levels of recession sensitivity and severity, and age, gender, gastric disease, and occlusal trauma were relevant factors for NCCL, CDH, and GR occurrence.

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