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ORIGINAL RESEARCH

Clinical Features of Non-Carious Cervical Lesions: An Observational Clinical Study

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Purpose: Non-carious cervical lesions (NCCLs) are among the most common dental pathologies observed in clinical practice. This study evaluated the clinical features of NCCLs in adult patients and assessed the relationship among age, lesion depth, dentin hypersensitivity (DHS), and sclerotic degree.

Patients and Methods: A total of 78 patients were recruited, resulting in 178 teeth with NCCLs. An interviewer-assisted questionnaire was administered to obtain sociodemographic information and possible risk factors for each participant. Clinical assessments of the different features of NCCLs were evaluated and recorded. Pearson's Correlation coefficient was used to investigate the relationship between age, lesion depth, sensitivity, and sclerotic degree. P-value of <0.05 was considered statistically significant at 95% CI.

Results: Most of the affected teeth were first premolar 74 (41.6%), and abrasion constituted about two-third of the NCCLs (69%). Half of the total teeth with NCCLs had occlusal surface wear (51.7%). One hundred and sixteen (65.2%) teeth presented with saucer-shaped lesions, while 62 (34.8%) were wedge-shaped. There was a moderate positive correlation between the age and lesion depth ($r = 0.394$, $p < 0.001$) and a moderate positive correlation between the age and sclerotic degree ($r = 0.408$, $p < 0.001$). The correlation between the DHS and lesion depth was moderate and positive ($r = 0.330$, $p < 0.001$). There was a negative correlation between DHS and the degree of sclerosis, but this was not statistically significant ($r = -0.075$, $p < 0.322$).

Conclusion: The present study demonstrated that most adult teeth with NCCLs presented with abrasions, occlusal surface wear facets, saucer-shaped lesions, with lesion depths greater than 2.0 mm. There were moderate positive correlations between age, lesion depth, DHS, sclerotic dentin, and lesion depth. However, there was a negative correlation between the DHS and the degree of sclerosis.

Keywords: dentin hypersensitivity, sclerosis, tooth sensitivity, abrasion, abfraction, erosive tooth wear

Introduction

Non-carious cervical lesions (NCCLs) refer to the loss of hard dental tissue located near the cemento-enamel junction (CEJ), with the distinctive feature of hard-mineralized tissue differentiating them from carious lesions.[1,2] NCCLs are prevalent clinical conditions that adversely affect both the structural integrity and pulpal health of teeth, in addition to compromising their aesthetic appearance and persistent dentinal sensitivity.[3] Therefore, NCCLs are frequently restored to replace the lost mineralized tooth substance and prevent further tissue loss.[4] NCCLs typically range from shallow grooves to significant large wedge-shaped defects with defined sharp line angles.[1]

The development of NCCLs has traditionally been attributed to toothbrush and dentifrice abrasion, whether or not there is an erosive factor involved.[5] However, literature has reported that dental abrasion, erosive tooth wear, and abfraction may contribute to the development of NCCLs.[5] Horizontal brushing was suggested to cause wear ranging up to three times compared with vertical brushing.[6] Abrasive lesions present with a linear outline that follows the path of

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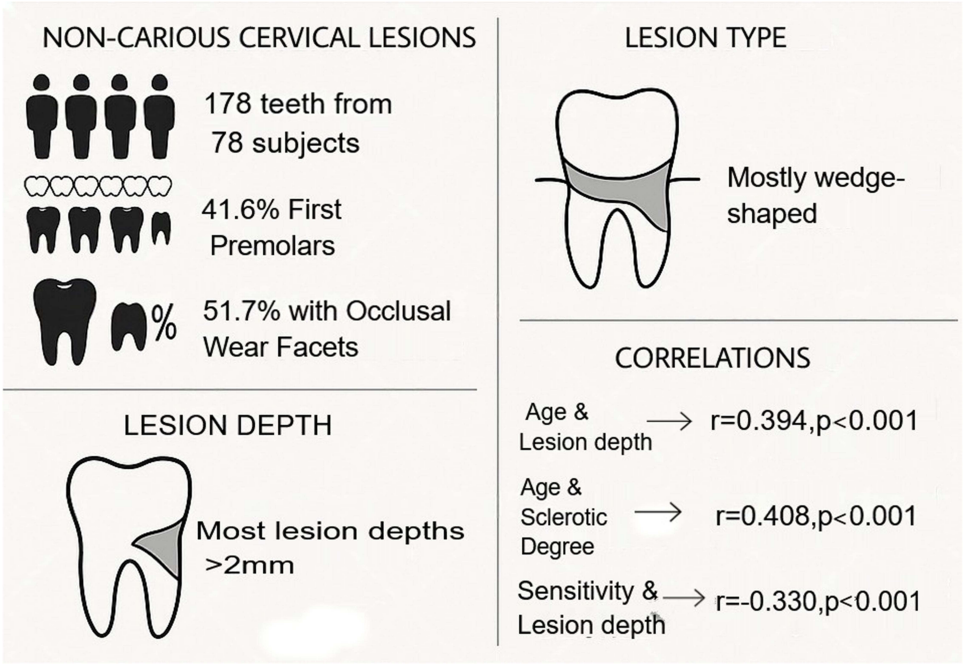
Graphical Abstract



brush bristles and the peripheries of the lesion are extremely angularly demarcated compared to the adjacent tooth surface.[6] Savage et al reported that horizontal tooth brushing was found to cause more tooth abrasion than vertical brushing technique.[7] The rate of abrasion is increased further with the use of hard-bristled toothbrush along with abrasive cleaning agents (eg. grounded charcoal, broken plates).[7]

The etiology of erosive tooth wear (ETW) is conventionally divided into "extrinsic" and "intrinsic" factors,[8] which present with a depression on the cervical areas of the anterior teeth, producing a saucer-shaped lesion that is smooth and rounded. The "extrinsic" factors include acidic products that are taken into the mouth, such as acidic fruits, carbonated drinks, which are high in acidic contents and also the occupational-related ETW, often caused by airborne acid that reaches the teeth, for example, in workers in certain industries, competitive swimmers, or people who are wine tasters.[8] The "intrinsic" factors include acids from within such as the gastric juice reaching the teeth due to various disease conditions like gastroesophageal reflux disease, which lead to reflux of acidic stomach content into the oral cavity, influencing and/or affecting the teeth.[8]

In 1984, a theoretical explanation for cervical wear was introduced and subsequently referred to as abfraction.[9] This terminology is based on their opinion that abfraction lesions were caused by tensile stress resulting from mastication and malocclusion formed along the cervical region.[9] The theory of abfraction suggests that tooth flexure in the cervical area is due to occlusal compressive forces and tensile stresses, resulting in micro-fractures of the hydroxyapatite crystals of the enamel and dentin with further fatigue and deformation of the tooth structure.[3] Abfraction lesions are found mainly on the buccal surfaces and are typically wedge-shaped (V-shaped) lesions with clearly defined internal and external angles.[3]

The lesions caused by abrasion and ETW were characterized by their smooth and rounded appearance, in contrast to the lesions caused by abfraction with wedge-shaped angular defects at the cervical region of the teeth.[9] However, some new studies observed an increase in the degree of tissue loss, which was dependent on both abrasiveness of the toothpaste and stiffness of the toothbrush, irrespective of occlusal forces.[10,11]

Research has shown that lesion characteristics such as morphology, depth, and degree of dentin sclerosis may influence the occurrence and intensity of hypersensitivity. Wedge-shaped lesions are frequently reported as the most

common morphological pattern, and deeper lesions may increase the likelihood of dentin exposure and sensitivity.[12] A study has suggested that lesion depth and morphology may contribute to increased sensitivity levels.[13] However, the relationship is not always linear, as dentin sclerosis that develops over time may reduce tubule permeability and thereby decrease sensitivity in older lesions.[14]

Some studies have reported the prevalence of NCCLs and the different possible etiological/risk factors associated with them, including their clinical features, in the Nigerian population.[7,15,16] However, studies that assess the relationship between age, tooth sensitivity, and some clinical features of NCCLs are still scarce; therefore, there is a need to further explore this in the Nigerian population. For this reason, the primary objectives of the present study were to evaluate the clinical features of NCCLs and the correlation among age, lesion depth, dentin hypersensitivity (DHS), and sclerotic degree.

Null Hypothesis (HO)

There is no significant relationship between age, lesion depth, dentin hypersensitivity (DHS), and the degree of dentin sclerosis in non-carious cervical lesions (NCCLs) among adult patients.

Patients and Methods

Design

This was a descriptive analysis and an observational clinical study conducted in compliance with the International Conference on Harmonization (ICH) Good Clinical Practice Guidelines and in accordance with the ethical principles that have their origins in the 1964 Declaration of Helsinki and its later amendments. Approval for the study (LREC/06/10/1278) was obtained from the Ethics Committee of the Lagos State University Teaching Hospital, Lagos State, Nigeria, on February 24, 2021. Each patient that participated in this study provided written informed consent after the procedures were fully explained to them.

Study Population/Selection Criteria

The study population consisted of patients diagnosed with NCCLs who were referred from the Oral Diagnosis Unit to the Conservative Dentistry outpatient clinic of the Department of Restorative Dentistry for screening and evaluation between February 2021 and February 2022. Patients were initially screened (88 patients) to meet the selection criteria mentioned below, and qualified patients were recruited for evaluation.

Patients aged ≥18 years with at least two non-carious lesions and lesions greater than 1 mm in depth were recruited. Patients with active, untreated periodontal disease, rampant, uncontrolled caries, non-vital teeth, previous root canal treatment, or teeth with periapical pathology were excluded. A total of 78 patients were recruited, resulting in 178 teeth with NCCLs evaluated.

Sample Size Calculation

The sample size was calculated by the study team biostatistician (G.E.A), using the following formula:

$$n = \frac{\left(Z_\alpha + Z_\beta\right)^2 \bar{\pi}(1-\bar{\pi})}{\Delta^2}$$

Where;

n = Sample size.

Zα =Standard normal deviation of α at the desired confidence level of 95%. When α = 0.05 (two-tailed test) = 1.96.

$\bar{\pi}$ = Proportion of NCCL that is wedge-shaped from previous study (ie, prevalence of wedge-shaped lesions is 76.0%) = 0.760.[12] We used the prevalence of wedge-shaped lesions considering that we are investigating lesion features and wedge-shaped NCCLs are the most common.

Zβ = Value of β error, which is 1- β (statistical power). At a statistical power of 80% and β error of 20%, zβ = 0.84.

Δ = Precision level 10% = 0.10

Therefore,

$$n = \frac{(1.96 + 0.84)^2 0.760(1 - 0.760)}{0.10^2}$$

$$n = \frac{7.84 \times 0.760(1 - 0.760)}{0.10^2}$$

n = 143.002 approximately 143

Thus, to achieve 80% power to detect significant correlations between the compared conditions with an alpha value of 0.05, a minimum sample size of 143 NCCLs was required.

Calibration of the Clinical Examiners

Two examiners (TES and COO) who performed the clinical assessment were calibrated by a Benchmark Examiner (TOO) experienced in the NCCL evaluation to ensure standardization and repeatability of all NCCLs assessments. The examiners were involved in a four-day calibration exercise using 10 patients attending the clinic, diagnosed as having at least one NCCL, and who were not included in the main study. Prior to calibration, 0.7 was established as the intra-examiner and inter-examiner agreement for qualification. The NCCL evaluation data collected during calibration were recorded, and the agreement between the Clinical Examiner and Benchmark Examiner for objective evaluation of NCCLs (inter-examiner) and between the Clinical Examiner's own repeated NCCL evaluations (intra-examiner) was evaluated using Bland-Altman plots and intra-class correlation coefficients. The two Clinical Examiners attained an inter-examiner of 0.85 and an intra-examiner score of 0.8.

Questionnaire Administration and Clinical Assessment

Questionnaire Administration

An interviewer-assisted questionnaire was administered to all the participants. Sociodemographic information and possible risk factors for each subject were noted: age, sex, occupation type, intake of carbonated drinks, technique of tooth brushing, type of toothpaste, frequency of tooth brushing, intensity of tooth brushing, and stiffness of the toothbrush.

Bradnock et al[17] categorized the occupations of the participants into two types based on the UK Adult Dental Health Survey, which was utilized in this study. The first three groups (I, II, and IIIN) were categorized as the first occupation type, and the second three groups (IIIM, IV, and V) were categorized as the second occupation type.

I. Professional (eg, doctor, dentist, lawyer),

II. Managerial (eg, manager, nurse, school teacher),

III N. Skilled, non-manual (eg, clerk, cashier, white-collar worker),

III M. Skilled, manual (eg, carpenter, bricklayer, machine operators),

IV. Semi-skilled, manual (eg, mail carrier, agricultural worker),

V. Unskilled, manual (eg, porter, general labourer).

Clinical Assessment

The NCCLs were identified using visual and tactile examinations. The following features were assessed: tooth involvement, NCCL type, presence of wear facets, and lesion morphology. The lesion depth was measured from the external cavo-surface margin of the cervical lesion to the deepest point of the lesion along a perpendicular axis to the tooth surface in millimeters using a calibrated periodontal probe.

NCCLs due to abrasion or erosive tooth wear (ETW) were differentiated based on a detailed patient medical and dental history and clinical examination. Clinically, abrasion-related lesions present with a linear outline that follows the path of the brush bristles, and the peripheries of the lesion are extremely angularly demarcated compared with the adjacent tooth surface. Furthermore, abrasion-related NCCLs were identified by their characteristic sharply defined V-shaped notches or saucer-shaped notches depending on the depth with smooth surfaces, typically located on the

buccal aspects of teeth and strongly associated with horizontal toothbrushing habits or use of abrasive toothpaste. In contrast, ETW-related NCCLs presented as rounded, shallow, and saucer-shaped defects with glossy surfaces, often affecting multiple teeth, and were associated with dietary acids (eg, frequent intake of carbonated drinks or citrus fruits).

The extent of sclerosis was evaluated by visual inspection and tactile feedback with a dental explorer to determine the extent of discoloration (yellow or brown), glassy appearance (shiny, hard, or smooth), and translucency or transparency of the enamel/dentin. The degree of sclerosis was assessed using the Dentin Sclerosis Scale ranging from 1 to 4.[18,19]

Category 1: No sclerosis present; dentin light yellowish or whitish with little discoloration; dentin opaque with little translucency or transparency.

Category 2: More sclerosis than Category 1 but less than half between Categories 1 and 4.

Category 3: Less sclerosis than category 4 but more than half between categories 1 and 4.

Category 4: Significant sclerosis present; dentin is dark yellow or even discolored (brownish); glassy appearance with significant translucency or transparency.

The sensitivity of the tooth with NCCLs was evaluated by applying a blast of air from an air-water jet at a distance of approximately 1 inch away with adjacent teeth under rubber dam isolation. Air was applied for a maximum of 5 s depending on the response. A Schiff Cold Air Sensitivity scale ranging from 0 to 3 was used as the standard index for the sensitivity evaluation.[20]

0 = Subject does not respond to air stimulus

1 = Subject responds to air stimulus but does not request discontinuation of stimulus

2 = Subject responds to air stimulus and requests discontinuation or moves from stimulus

3 = Subject responds to air stimulus, considers stimulus to be painful and requests discontinuation of the stimulus

Statistical Analysis

Data entry and analysis were performed using Statistical Product and Services Solution (IBM SPSS) version 27.0. Categorical variables were presented as frequencies and percentages, whereas numeric data were presented as means and standard deviations for normally distributed data. Pearson's Correlation coefficient was used to investigate the relationship between age, lesion depth, sensitivity, and sclerotic degree. All tests were performed at the 5% significance level (95% confidence interval). Statistical significance was set at $p < 0.05$.

Results

Most of the patients were (54; 69.2%) male, and the age group with the highest number of NCCLs (48; 61.5%) was 41–60 years, while the age group with the least number of NCCLs was ≤40 years (Table 1).

More than half of the patients (42; 53.9%) used a medium-textured toothbrush, 30 (38.4%) used both vertical and horizontal brushing techniques, and 40 (51.3%) brushed their teeth twice daily (Table 2).

Most of the affected teeth were first premolar (74; 41.6%), followed by second premolar (38; 21.3%), while only two (1.1%) lateral incisors presented with NCCLs. Sixty (33.7%) of these lesions occurred in the mandible, while 118 (66.3%) occurred in the maxilla. The lesions were observed more on the right side (92; 51.7%) compared to the left side (86; 48.3%) (Table 3).

Abrasion constituted about two-third of the NCCLs (69%), followed by abfraction (27%) and erosion (4%) (Figure 1). Half of the total teeth with NCCLs had occlusal surface wear (51.7%). One hundred and sixteen (65.2%) teeth presented with saucer-shaped lesions, while 62 (34.8%) were wedge-shaped. The mean (±SD) lesion depth was 2.5 (±0.6) mm. Most of the teeth (68; 38.2%) had a sensitivity score of 0 in which there was no response to air stimulus by the patients, whereas only 3 (9.6%) had a score of 2 (patients responded to air stimulus and requested discontinuation or moves from stimulus); howbeit, 17 (21.9%) had a score of 3 (patients responded to air stimulus, considers stimulus to be painful and requested discontinuation of the stimulus). Most NCCLs had a sclerotic degree in category 2 (88; 49.5%), while category four had the lowest (Table 3).

Table 1 Socio-Demographic Features of the Patients

Variables	Frequency (N=78)	Percentage (%)
Gender		
Male	54	69.2
Female	24	30.8
Age group (Years)		
≤40	6	7.7
41–60	48	61.5
>60	24	30.8
Age Range	28–79	
Mean SD	53.0±11.0	
Occupation		
Professionals	22	28.2
Manager/lower professional	40	51.3
Skilled non manual	2	2.6
Skilled manual	4	5.1
Unskilled	10	12.8

Table 2 Pattern of Tooth Brushing Among Patients

Variables	Frequency (N=78)	Percentage (%)
Types of Tooth brush bristle		
Hard	30	38.4
Medium	42	53.9
Soft	6	7.7
Techniques of Toothbrushing		
Horizontal	29	37.2
Vertical	19	24.4
Both	30	38.4
Frequency of Toothbrushing		
Once	38	48.7
Twice	40	51.3
Intensity of Toothbrushing		
High	42	53.8
Medium	36	46.2

Table 3 Characteristic of NCCL in Teeth Studied

Variable	Frequency (N=178)	Percentage (%)
Tooth Types		
Central Incisor	12	6.7
Lateral incisor	2	1.1
Canine	30	16.9
First Premolar	74	41.6
Second Premolar	38	21.3
First Molar	18	10.1
Second Molar	4	2.2

(*Continued*)

Table 3 (Continued).

Variable	Frequency (N=178)	Percentage (%)
Side		
Left	86	48.3
Right	92	51.7
Jaw		
Upper	118	66.3
Lower	60	33.7
Occlusal Wear Facet		
Yes	92	51.7
Nil	86	48.3
Lesion Morphology		
Saucer	116	65.2
Wedge	62	34.8
Lesion Depth (mm)		
1–2	70	39.3
>2	108	60.7
Mean±SD = 2.5±0.6		
Dentin hypersensitivity		
0		38.2
1		30.3
2		9.6
3		21.9
Sclerotic Degree		
Category One	25	14.0
Category Two	88	49.5
Category Three	57	32.0
Category Four	8	4.5

There was a moderately positive correlation between age and lesion depth ($r = 0.394$, $p < 0.001$). There was also a moderate positive correlation between age and the sclerotic degree ($r = 0.408$, $p < 0.001$). The correlation between the DHS and lesion depth was moderate and positive ($r = 0.330$, $p < 0.001$). There was a negative correlation between DHS and the degree of sclerosis; however, this was not statistically significant ($r = -0.075$, $p < 0.322$) (Table 4).

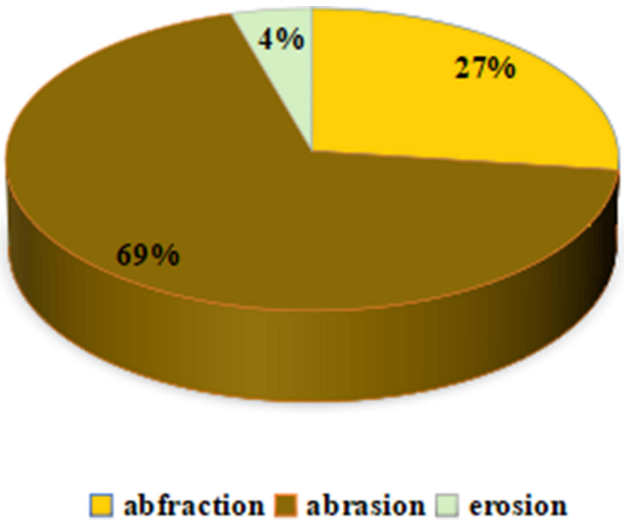


Figure 1 Types of Non-carious cervical lesions.

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Table 4 Correlation Matrix Depicting the Relationship Between Age, Sensitivity, Lesion Depth, and Sclerotic Degree

	Lesion Depth (r)	P	Sclerotic Degree (r)	P
Age	0.394	0.001*	0.408	0.001*
Dentin hypersensitivity	0.330	0.001*	−0.075	0.322

Note: *Statistically significant; r = correlation coefficient.

Discussion

Non-carious cervical lesion (NCCL) is a multifactorial condition that has become increasingly prevalent in modern dental practice, especially among adults and elderly individuals. Understanding the clinical features of NCCLs is important for accurate diagnosis, effective management, and prevention of further progression. In the present study, an interviewer-assisted questionnaire was administered to the participants for sociodemographic information and possible risk factors associated with NCCLs, while clinical assessment was performed to evaluate the features of NCCLs.

This study showed a higher percentage of NCCLs among male patients (69.2%), which was also observed in similar studies,[21–23] but in contrast to a study by Dilsad et al[24] This might be explained by the fact that males tend to use hard-textured toothbrushes, with excessive brushing force, consequently increasing the wear on the cervical buccal surfaces.[25,26] In addition, males tend to have greater masticatory strength that generates a higher stress concentration, which makes the tooth structure more susceptible to other risk factors.[27] NCCLs were frequently observed in more advanced age groups (41–60), which was also recorded in other studies.[12,22] Nonetheless, this is anticipated in older patients as their teeth have been subjected to the relevant etiological factors for a significantly longer duration compared to younger patients. A study suggested that men aged 65–74 years who frequently used toothpicks, consumed vinegar drinks, ate hard foods, and had not visited a dentist for over a year were more likely to have a higher incidence of NCCL in their teeth.[28]

The patients in this study presented with NCCLs that were mostly caused by abrasion (69%). Dental hygiene habits, including the frequency of daily brushing, the technique used, intensity of tooth brushing and the stiffness of the bristles, are considered potential risk factors in the development of dental abrasion.[29] Our study revealed incidence of 92.3% among patients with NCCLs using hard/medium bristle toothbrush, 75.6% applied horizontal and both horizontal/vertical brushing techniques and over 50% demonstrated high intensity while brushing their teeth. Moreover, horizontal scrubs may be more damaging because of their opposing nature to developmental lines on the tooth surface in the cervical region.

The first premolars (41.6%) were the tooth type most commonly affected by NCCL, followed by the canines (16.9%). This is in agreement with the report of a study carried out in adult Nigerian population, which suggested that the first premolar and canine can be considered as "transitional" teeth between the anterior and posterior teeth that are accessible to toothbrush and brushing mechanics, resulting in prolonged contact with the toothbrush, which allows generation of maximum force in these areas.[30] It may also be attributed to the presence of a bony anatomical deficiency on the facial prominence of the first premolars, which makes them more susceptible to gingival recession and abrasion.[5] Non-carious cervical lesions were more frequently observed in the maxillary teeth as opposed to the mandibular teeth. This is consistent with the findings of previous studies.[12,31] This could be linked to the fact that most patients commence their tooth cleaning routine with maxillary teeth, experiencing a gradual decrease in force as the process continues.[30] An additional possible explanation is that the maxillary teeth overlap with the mandibular teeth; consequently, the toothbrush has more contact with the maxillary teeth when brushing.[31]

The findings of the present study showed that more than half of the teeth with NCCLs had occlusal wear facets. Studies have shown that Eccentric occlusal loads are associated with the presence of NCCLs and this association is based on the presence of occlusal wear facets.[32,33] Nevertheless, the available data remain inadequate and/or ambiguous because the majority of studies supporting this association lack a robust evidence base.[13]

A study carried out in China revealed a strong association between NCCLs and dentin hypersensitivity.[34] Nonetheless, the literature remains sparse regarding the correlation between the depth of NCCLs and levels of DHS.[13] However, the present study showed a moderate positive correlation between the depth of NCCLs and DHS, which was corroborated by

a study conducted in Brazil.[13] These findings could be attributed to the proximity of the bottom wall of the lesion with the pulp (in deeper lesions) and by the extent of exposed dentinal tubules, which intensifies the painful reaction.[35]

Furthermore, the present study showed a moderate positive correlation between age and the sclerotic degree. Sclerotic dentin, which can be described as translucent or transparent dentin, becomes more prevalent with increasing age. The sclerotic dentin is as a result of accumulation of mineral deposits within the dentinal tubules, making them less permeable and giving them a translucent appearance under transmitted light.[36] Although it increases with age, it is not exclusively as a result of aging process itself, it can be triggered by consistent trauma to tooth surface.[36] There was a moderate positive correlation between the age and lesion depth in the present study. NCCLs are not only prevalent among older adults; lesion depth tends to increase with age. Studies have shown a significant association between age and disease severity in terms of the shape and depth of the NCCLs.[30,37] Thus, the H0 hypothesis was rejected, there were positive correlations between age and lesion depth; age and sclerotic dentin; and DHS and depth of NCCLs.

Studies have reported that the prevalence and severity of NCCLs increase with advancing age. This trend is generally attributed to the cumulative effect of mechanical, chemical, and biomechanical factors such as tooth brushing abrasion, dietary erosion, and occlusal stress over time. As individuals age, the prolonged exposure of teeth to these etiological factors contributes to gradual loss of cervical tooth structure and the development of deeper lesions.[13,14,38]

In the present study, there was a negative correlation between DHS and the degree of sclerosis, but this was not statistically significant. Thus, the H0 hypothesis was not rejected. This showed that, as the sclerotic degree increased, the DHS in the cervical region decreased. This can be linked to the fact that NCCLs progressively become less sensitive over time because of the formation of reparative or sclerotic dentin.[39] However, the negative correlation was not significant, and further studies are recommended.

This study did not include quantitative dietary analysis, occlusal force measurements, or detailed evaluation of parafunctional habits, which are known contributors to NCCL development. The absence of these variables may limit a comprehensive understanding of all potential risk factors associated with the lesions. Despite these limitations, the study provides valuable clinical insights into the characteristics of NCCLs and their relationship with age, lesion depth, dentin hypersensitivity, and dentin sclerosis in an adult patient population. Recognizing the potential risk factors associated with NCCL and its features is crucial for the accurate diagnosis, prevention, and effective clinical management of this condition, thereby improving the patients' quality of life.

Conclusion

The majority of adult teeth with NCCLs presented with abrasions, occlusal surface wear facets, and saucer-shaped lesions, with lesion depths greater than 2 mm. Moderate positive correlations were observed between age and lesion depth, age and sclerotic dentin as well as DHS and lesion depth. There was a negative correlation between the DHS and the degree of sclerosis, but this was not statistically significant. The outcome of the present study is of clinical importance because it enhances the understanding of the etiological factors, morphological patterns, and diagnostic features of non-carious cervical lesions, consequently improving the accuracy of diagnosis and the selection of appropriate restorative approaches.

Disclosure

All authors declare no conflicts of interest in this work.

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