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The Role of Occlusal Factors in the Presence of Noncarious Cervical Lesions in Young People: A Case-Control Study

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Clinical Relevance

Some occlusal factors such as protrusive and non–working-side lateral interferences, as well as bruxism, are risk factors for the presence and development of noncarious cervical lesions.

SUMMARY

Objective: The aim of this retrospective case-control study was to evaluate the influence of different occlusal characteristics and self-referred bruxism in the presence of noncarious cervical lesions (NCCLs).

Methods and Materials: The participants were 280 students (140 cases and 140 controls), with an average age of 24.5 years, from six schools of dentistry in Spain. Clinical examination was carried out to record the NCCLs and the static and dynamic occlusal characteristics. The side of mastication and bruxism was collected by questionnaire. Data variables were analyzed by means of univariate and multivariate logistic regression. Odds ratios and the respective 95% confidence intervals were calculated ($p<0.05$).

Results: The presence of NCCLs was significantly more likely in subjects with protrusive interferences (odds ratio [OR]=1.82); with lateral interferences, especially on the nonworking side (OR= 1.77); or who were self-reported bruxists (OR=1.72). In the multivariate analysis, protrusive interferences, bruxism, age, and the presence of attrition were risk factors for the development of NCCLs. These factors re-

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sulted in a model with an area under the receiver-operating characteristic curve of 0.667 and a positive predictive value of 61.43%.

Conclusions: There was no significant relationship between most occlusal factors and the presence of NCCLs. Only bruxism, protrusive interferences, age, and occlusal wear were risk factors. The predictive model was not sufficiently explanatory. Occlusal factors alone do not appear to be sufficient to explain the presence of NCCLs.

INTRODUCTION

The etiology or risk factors that may influence the initiation and progression of noncarious cervical lesions (NCCLs) is a topic under discussion. Numerous studies with different designs support the multifactorial etiology of these lesions, whether they are cross-sectional studies,[1-4] clinical trials,[5-7] systematic reviews,[8-11] or simply informative texts.[12-14] Thus, several factors alone or in combination and with different mechanisms of action can contribute to the onset and progression of tooth structure loss at the cementoenamel junction (CEJ). Wear in the cervical region of a tooth is most commonly related to factors that can cause dental erosion or biocorrosion (chemical degradation of the enamel due to the presence of exogenous or endogenous acids), abrasion (mechanical wear related to brushing factors), and abfraction (disruption of the enamel hydroxyapatite crystals due to increased stress of occlusal origin).[5,9,10-12,14-16] However, the scientific evidence reported in a recent systematic review[8] shows that the multifactorial etiology is insufficient and not at a very high level. Furthermore, in the dental literature, most of the studies were cross-sectional; no randomized clinical trials or cohort studies, and only two case-controls studies[7,17] were found. Therefore, the relationship between risk factors and the onset and progression of NCCLs is controversial and not sufficiently clarified. NCCLs can be a major public dental health problem, with the prevalence in samples representative of the population in a range between 31.6% and 81.3% in the oldest age group.[1-3,18] When the sample is not representative and the subjects are dental students, military people, or patients of dental clinics or schools and of smaller sample size, high prevalences in the range of 39% to 67.8% are also reported.[15,16,19-21] However, the prevalence of teeth with occlusal disturbances or attrition in the presence of NCCLs is not frequently reported. In a sample of 2707 subjects and 54,204 teeth, only 19.5%-23.9% of teeth with NCCL showed contacts in protrusion or laterotrusion, and 23.6% of teeth with NCCLs had neither occlusal nor incisal facets.[3]

Possible risk factors of an occlusal nature or related to parafunctional activities are generally assumed by practitioners, but they are also under discussion. During the parafunctional activity of clenching or grinding teeth, increased tooth contact occurs as a result of a greater, more prolonged contraction force of the masticatory muscles compared with during chewing or swallowing. This increase in the occlusal load is transformed to compression, tensile, or shear stress, which, when located in the cervical area of a tooth, can deform it and cause disruption of the joints of the enamel hydroxyapatite crystals, thus initiating an NCCL. A thin layer of enamel in this area, lower mineral content, larger pores, and higher protein content found in the cervical enamel compared with the occlusal enamel favor demineralization in the cementum-enamel union. In addition, *in vivo* and *in vitro* biomechanical studies support the existence of stress concentration in the CEJ (in the cervical region of the tooth).[22-28] Different clinical studies report the importance and association of bruxism with NCCLs,[2,7,20,29,30] while others find no greater percentage or risk of NCCLs in subjects with self-reported bruxism compared with nonbruxers.[1,16,31]

As with parafunctional activity, occlusal disorders, especially premature contacts and occlusal interferences in excursive movements, and the type of guidance may increase the occlusal load and with it stress in the cervical region of the teeth. The progression of NCCLs has been linked to increased occlusal forces,[16,32] with a greater area of occlusal contact,[16] and with some occlusal disorders or characteristics.[15,17,19,33,34] By contrast, other clinical, review, and *in vitro* studies reject or question the role of occlusal factors in the development of NCCLs.[8,9,30,33,35-37]

Consequently, although numerous studies have been carried out over a period of many years to clarify the role played by occlusion and bruxism in the onset and development of NCCLs, this role remains unknown. There is neither sufficient nor strong enough evidence to support an association between NCCLs and occlusal disorders or bruxism.[8,9,11,22,33] Most of the available studies are cross-sectional with nonrepresentative samples, inadequate sample sizes, significant variability in ages and method of recording, and also heterogeneity of the independent variables (occlusal disturbances) and lack of control confounders. Studies with a

Table 1: *Univariate Logistic Regression: Distribution of the Sample According to Age, Sex, and Static Occlusal Factors*

Variable, Occlusion	Cases, n (%)			Controls, n (%)			OR	*p* Value
	Males	Females	Total	Males	Females	Total	(95% CI)	
n (%)	53 (18.9)	87 (31.1)	140 (50.0)	53 (18.9)	87 (31.1)	140 (50.0)	1 (0.62-1.62)	0.980
Age, y								0.432
18-20	7 (13.21)	16 (18.39)	23 (16.43)	11 (20.75)	9 (10.34)	20 (14.29)	Reference category	
21-23	27 (50.94)	49 (56.32)	76 (54.29)	31 (58.49)	56 (64.37)	87 (62.14)	0.76 (0.39-1.49)	0.424
24-26	9 (16.98)	16 (18.39)	25 (17.86)	8 (15.09)	19 (21.84)	27 (19.29)	0.80 (0.36-1.81)	0.600
27-29	10 (18.87)	6 (6.90)	16 (11.43)	3 (5.66)	3 (3.45)	6 (4.29)	2.32 (0.76-7.05)	0.139
Chewing side								0.616
Right	14 (26.42)	27 (31.03)	41 (29.29)	17 (32.08)	32 (36.78)	49 (35.00)	Reference category	
Left	8 (15.09)	13 (14.94)	21 (15.00)	8 (15.09)	13 (14.94)	21 (15.00)	1.19 (0.57-2.49)	0.634
Both	26 (49.06)	33 (37.93)	59 (42.14)	21 (39.62)	31 (35.63)	52 (37.14)	1.35 (0.77-2.37	0.285
DK/NA	5 (9.3)	14 (16.09)	19 (13.57)	7 (13.21)	11 (12.64)	18 (12.86)	1.26 (0.58-2.71)	0.553
Angle's malocclusion classification								0.531
Class I	33 (62.26)	56 (64.37)	89 (63.57)	35 (66.04)	65 (74.71)	100 (71.43)	Reference category	
Class II	15 (28.30)	22 (25.29)	37 (26.43)	14 (26.42)	13 (14.94)	27 (19.29)	1.54 (0.87-2.72)	0.139
Class III	5 (9.43)	9 (10.34)	14 (10.00)	4 (7.55)	9 (10.34)	13 (9.29)	1.21 (0.54-2.71)	0.643
Overbite								0.790
No	36 (67.92)	64 (73.56)	100 (71.43)	39 (73.58)	63 (72.41)	102 (72.86)	Reference category	
Yes	17 (32.08)	23 (26.44)	40 (28.57)	14 (26.42)	24 (27.59)	38 (27.14)	1.07 (0.64-1.81)	
Overjet								0.223
No	31 (58.49)	48 (55.17)	79 (56.43)	33 (62.26)	56 (64.37)	89 (63.57)	Reference category	
Yes	22 (41.51)	39 (44.83)	61 (43.57)	20 (37.74)	31 (35.63)	51 (36.43)	1.35 (0.83-2.18)	
Crossbite								0.728
No	47 (88.68)	78 (89.66)	125 (89.29)	50 (94.34)	73 (83.91)	123 (87.86)	Reference category	
Anterior	3 (5.66)	3 (3.45)	6 (4.29)	1 (1.89)	5 (5.75)	6 (4.29)	0.98 (0.31-3.13)	0.978
Posterior	3 (5.66)	6 (6.90)	9 (6.43)	2 (3.77)	9 (10.34)	11 (7.86)	0.80 (0.32-2.01)	0.643
Protrusive guidance								0.557
No	3 (5.66)	4 (4.60)	7 (5.00)	4 (7.55)	1 (1.15)	5 (83.57)	Reference category	
Yes	50 (94.34)	83 (95.40)	133 (95.00)	49 (92.45)	86 (98.85)	135 (96.43)	0.70 (0.21-2.27)	

Abbreviations: CI, confidence interval; DK, doesn't know; NA, no answer; OR, odds ratio.

higher level of evidence (case-control) are also inconclusive, reporting as a risk factor only the right canine guidance[7] or significant differences with premature contacts and working-side contacts but not in balancing and protrusion.[17] The progression of NCCLs did not improve as a result of occlusal adjustment of the group function during lateral excursive movements performed in a clinical trial,[33] nor did the presence of premature contacts in centric relation in a control group design influence the development of NCCLs.[35] All of this makes it difficult to identify a causal relationship between NCCLs and occlusal factors.

In keeping with this, the null hypothesis established was that self-reported bruxism and occlusal alterations (occlusal factors) are not risk factors for the development of NCCLs. In addition, the aim of this study was to identify, through a case-control design with univariate and multivariate logistic regression analysis, whether bruxism and different static and dynamic occlusal factors are significantly associated with NCCLs, to show the intensity of such an association, and to formulate a predictive model.

METHODS AND MATERIALS

Participants in the study were 280 (140 cases and 140 controls) undergraduate dental students from six randomly selected schools of dentistry in Spain. The students of each faculty were invited to participate in the study; those who responded positively were selected to form the sample. Table 1 shows the distribution according to age and sex. The dental literature reveals great variability in the prevalence of NCCLs owing to their complexity and

multifactorial etiology. The variability in the selection of the sample and sample size, the nonhomogenization of the participants' ages, greater exposure to certain risk factors, as well as geographical, cultural, and socioeconomic factors are some of the factors that contribute to the indeterminacy of the prevalence. Therefore, the prevalence of NCCL cases is not known. With this assumption, the authors opted for a prevalence of 50% between cases and a moderate odds ratio (OR=2) to estimate the prevalence between controls. Thus, the maximum sample size was obtained for the quoted percentage. Without the Yates correction, a sample size of 274 subjects was obtained for a confidence level of 95% and a power (1 − "β) of 80%. Cases and controls were selected in an initial clinical examination (approximately 50 per school of dentistry). Subjects in whom the explorer detected cervical wear of any shape corresponding to a score of 2 (defect less than 1-mm deep) or more on the Tooth Wear Index classification of Smith and Knight were considered as cases.[38] Detection was visual or by means of a periodontal probe. The tip of the probe was positioned perpendicular to the surface of the tooth, and from the bottom of the gingival sulcus, it was moved along the CEJ to approximately half of the coronal height. If a gap was noticed, it was considered an NCCL. For each case, a control of the same sex and similar age was selected. In addition, exclusion criteria included absence of any tooth except the wisdom teeth, orthodontic treatment at the date of clinical examination, presence of prosthetic restorations restorations or caries in the cervical region of the teeth. Before the selection of participants, an Institutional Review Board approved the study data collection protocol. All participants also signed informed consent.

After the cases and controls were selected, each participant responded to an ad hoc questionnaire, and their responses were recorded. The questionnaire was similar to the one used in the different studies that have evaluated risk factors of NCCLs and included questions about whether the participant clenched or ground their teeth and their preferred chewing side, in addition to issues related to other possible risk factors (exogenous or endogenous acids and brushing habits). The occlusal clinical examination was then performed. This included the exploration of static occlusal parameters (Angle's malocclusion, overjet, overbite, and crossbite), dynamic parameters (interferences in excursive movements and occlusal guides for protrusion and lateral mandibular movements), and attrition evaluated by visual examination of the occlusal surface of the teeth. The occlusal guides and contacts were recorded with 40-μm articulating paper (Bausch Arti-Check, Bausch Articulating Papers Inc, Nashua, NH, USA).

Based on the questionnaire and the clinical examination, 16 independent occlusal variables were collected (see Tables 1 and 2). All participants were examined in a dental chair using the equipment light, dental mirrors, and periodontal probe calibrated in millimeters. At each school of dentistry, a single trained dentist (associate professor), assisted by a dental hygienist, carried out the clinical examinations to select cases and controls. The examiners were calibrated as follows: all examiners were informed in a previous ad hoc protocol of the strategy of data collection. Subsequently, 14 subjects randomly selected from the cases and controls of the School of Dentistry of Madrid were examined by the gold standard (occlusion expert). On different days, the same subjects were evaluated by the examiner of each school of dentistry, and the results for excursive movement interferences and NCCL or non-NCCL items were compared with the gold standard using Cohen's kappa coefficient. The average results of the interobserver variability with respect to the gold standard were 0.82 for the NCCLs and 0.81 for interferences in excursive movements. A repeat examination with the same subjects to measure intraexaminer variability was performed at three weeks by each examiner. The results were compared with the previous examination, giving average results of 0.89 and 0.85, respectively.

In the data analysis, only the independent or predictor variables related to occlusal factors, bruxism, and attrition (occlusal wear) were used. All study variables were analyzed in both the univariate and multivariate logistic regression analysis. The OR and 95% confidence interval (CI) were calculated. The level of statistical significance was set at 0.05. Statistical analysis was carried out using the software Stata v.13 (StataCorp LLC, College Station, TX, USA).

RESULTS

Tables 1 and 2 show the distribution of cases and controls according to age and sex, the distribution of the different occlusal factors, and the results of the univariate logistic regression analysis. Of all variables related to occlusion, only participants with protrusive interferences, with nonworking side interferences both in right and left lateral movements, or with interferences on the nonworking side,

Table 2: *Univariate Logistic Regression: Distribution of the Sample According to Dynamic Occlusal Factors and Bruxism*

Variable, Occlusion	Cases, n (%)			Controls, n (%)			OR	*p* Value
	Males	Females	Total	Males	Females	Total	(95% CI)	
Right canine guidance								0.631
No	1 (1.89)	8 (9.20)	9 (6.43)	5 (9.43)	6 (6.90)	11 (7.86)	Reference category	
Yes	14 (26.42)	24 (27.59)	38 (27.14)	13 (24.53)	24 (27.59)	37 (26.43)	1.25 (0.46-3.37)	0.653
Group function	38 (71.60)	55 (63.22)	93 (66.43)	35 (66.04)	57 (65.54)	92 (65.71)	1.23 (0.49-3.12)	0.655
Left canine guidance								0.371
No	3 (5.66)	8 (9.20)	11 (7.86)	4 (7.45)	3 (3.55)	7 (5.00)	Reference category	
Yes	11 (20.75)	25 (28.74)	36 (25.71)	17 (32.98)	37 (42.53)	54 (38.57)	1.25 (0.46-3.37)	0.109
Group function	39 (73.58)	54 (62.07)	93 (66.43)	32 (60.38)	47 (54.02)	79 (56.43)	1.23 (0.49-3.12)	0.560
Protrusive interferences								0.018
No	30 (56.60)	53 (58.62)	83 (57.86)	38 (71.70)	62 (71.26)	100 (71.43)	Reference category	
Yes	23 (43.40)	36 (41.38)	59 (42.14)	15 (28.30)	25 (28.74)	40 (28.57)	1.82 (1.11-2.99)	
Right laterality interferences								0.178
No	27 (50.94)	43 (49.43)	70 (50.00)	34 (64.15)	55 (63.22)	89 (63.57)	Reference category	
Working side	8 (15.09)	11 (12.64)	19 (13.57)	9 (16.98	11 (12.64)	20 (14.29)	1.21 (0.59-2.43)	0.598
Nonworking side	12 (22.64)	22 (25.29)	34 (24.29)	7 (13.21)	15 (17.24)	22 (15.71)	1.96 (1.06-3.65)	0.033
Both	6 (11.32)	11 (12.64)	17 (12.14)	3 (5.66)	6 (6.90)	9 (6.43)	2.40 (1.01-5.71)	0.048
Left laterality interferences								0.181
No	25 (47.17)	45 (51.72)	70 (50.00)	38 (71.70)	50 (57.47)	88 (62.86)	Reference category	
Working side	6 (11.32)	10 (11.49)	16 (11.43)	6 (11.32)	11 (12.64)	17 (12.14)	1.18 (0.56-2.51)	0.661
Nonworking side	14 (26.42)	24 (27.59)	38 (27.14)	7 (13.21)	19 (21.84)	26 (18.57)	1.82 (1.02-3.31)	0.043
Both	8 (15.09)	8 (9.20)	16 (11.43)	2 (3.77)	7 (8.05)	9 (6.43)	2.23 (0.93-5.36)	0.072
Laterality interferences in Non-working side								0.020
No	28 (52.83)	47 (54.02)	75 (53.57)	40 (75.47)	54 (62.07)	94 (67.14)	Reference category	
Yes	25 (47.17)	40 (45.98)	65 (46.43)	13 (24.53)	33 (37.93)	46 (32.86)	1.77 (1.09-2.87)	
Laterality interferences in Working side								0.301
No	35 (66.04)	58 (66.67)	93 (66.43)	38 (71.70)	63 (72.41)	101 (72.14)	Reference category	
Yes	18 (33.96)	29 (33.33)	47 (33.57)	15 (28.30)	22 (25.90)	39 (27.86)	1.31 (0.78-2.18)	
Bruxism								0.0193
No	20 (14.28)	24 (17.14)	44 (31.43)	23 (16.43)	38 (27.15)	61 (43.57)	Reference category	
Diurnal	11 (7.86)	15 (10.74)	26 (18.57)	8 (5.71)	12 (8.57)	20 (14.28)	1.80 (0.89-3.62)	
Nocturnal	13 (9.29)	19 (13.57)	32 (22.85)	15 (10.71)	24 (17.14)	39 (27.86)	1.14 (0.62-2.08)	
Both	9 (6.43)	29 (20.71)	38 (27.14)	7 (5.00)	13 (9.28)	20 (14.28)	2.63 (1.35-5.12)	0.004
Attrition								0.070
No	37 (69.81)	52 (59.77)	89 (63.57)	38 (71.70)	65 (74.71)	103 (73.57)	Reference category	
Yes	16 (30.19)	35 (40.23)	51 (36.43)	15 (28.30)	22 (25.29)	37 (26.43)	1.59 (0.65-1.14)	

Abbreviations: CI, confidence interval; DK, doesn't know; NA, no answer; OR, odds ratio.

regardless of the lateral movement direction, showed significantly more chance of suffering NCCLs, with an OR value in the range of 1.77 to 1.96, depending on the variable considered (see Table 1). Likewise, subjects who reported being bruxers had significantly more NCCLs than nonbruxers with OR=2.63 (CI=1.35-5.12; p=0.0193). It may be that some of the occlusal factors were not significant simply because the reference category was too small. A larger sample size with a greater population in the categories could reach statistical significance. Table 3 shows the distribution of cases and controls according to dietary type, brushing habits, and the presence of gastroesophageal diseases.

Data from the multivariate logistic regression analysis showed that risk factors in the presence of NCCLs were protrusive interferences (OR=1.93; CI=1.12-3.22; p=0.017), bruxism (OR=1.72; CI=1.01-2.96; p=0.048) and, to a lesser extent, age (OR=1.16; CI=1.04-1.29; p=0.008) and occlusal wear

Table 3: *Univariate Logistic Regression: Distribution of Cases and Controls According Dietary Type, Brushing Habits, and the Presence of Gastroesophageal Diseases*

Variable, Dietary, Brushing, and GERD	Cases, n (%)			Controls, n (%)			OR	*p* Value
	Males	Females	Total	Males	Females	Total	(95% CI)	
Frequency of brushing								0.475
Maximum twice daily	14 (10.00)	19 (13.57)	33 (23.57)	9 (6.43)	14 (10.00)	23 (16.43)	Reference category	
More than twice daily	39 (27.86)	68 (12.86)	107 (76.43)	44 (31.43)	73 (52.14)	117 (83.57)	0.64 (0.35-1.20)	
Brush bristles hardness								0.280
Smooth/medium	41 (29.29)	74 (52.86)	115 (82.14)	44 (31.43)	81 (57.86)	125 (88.57)	Reference category	
Hard	11 (7.86)	11 (7.86)	22 (15.72)	9 (6.43)	6 (4.29)	15 (10.43)	1.59 (0.79-3.22)	0.194
DK/NA	1 (0.71)	2 (1.43)	3 (2.14)	0 (0.00)	0 (0.00)	0 (0.00)	—	—
Brushing technique								0.714
Vertical/variable	46 (32.86)	76 (54.26)	122 (87.14)	47 (31.57)	77 (57.00)	124 (88.57)	Reference category	
Horizontal	7 (5.00)	11 (7.86)	18 (12.86)	6 (4.28)	10 (7.14)	16 (11.43)	1.14 (0.55-2.34)	
Consumption of soft drinks/day								0.638
Any	25 (17.86)	36 (25.71)	61 (43.57)	22 (15.71)	43 (30.71)	65 (46.43)	Reference category	
Once	21 (15.00)	34 (24.28)	55 (39.28)	21 (15.00)	34 (24.28)	55 (39.29)	1.06 (0.64-1.77)	0.808
Twice or more	7 (5.00)	17 (12.14)	24 (17.14)	10 (7.14)	10 (7.14)	20 (14.28)	1.28 (0.64-2.54)	0.484
Consumption of acidic or citrus fruits/day								0.376
Any	26 (18.57)	30 (21.43)	56 (40.00)	21 (15.00)	45 (32.14)	66 (47.14)	Reference category	0.
Maximum twice daily	23 (16.43)	43 (30.71)	66 (47.14)	29 (20.71)	34 (24.28)	63 (45.00)	1.23 (0.75-2.03)	0.401
More than twice daily	4 (2.86)	14 (10.00)	18 (12.86)	3 (2.14)	8 (5.71)	11 (7.86)	1.93 (0.84-4.42)	0.121
Vomiting or gastroesophageal reflux/day								0.802
No	52 (37.14)	80 (57.14)	132 (94.29)	49 (35.00)	82 (58.57)	131 (93.57)	Reference category	
Yes	1 (0.71)	7 (5.00)	8 (5.71)	4 (2.86)	5 (3.57)	9 (6.43)	0.88 (0.33-2.35)	

Abbreviations: CI, confidence interval; DK, doesn't know; GERD, gastroesophageal reflux disease; NA, no answer; OR, odds ratio.

(OR=1.07; CI=1.01-1.13; p=0.014; Table 4). In addition, the model obtained has an area under the receiver-operating characteristic (ROC) curve of 0.667, sensitivity of 60.71%, specificity of 67.14%, and correctly classifies 61.43% of the cases. These values place the model in an intermediate position between the ideal model with the curve near the top left-hand corner with 100% sensitivity and specificity and the worst model represented by the diagonal drawn from the bottom left-hand corner to the top right-hand corner (Figure 1). The behavior of the tendencies of sensitivity and specificity according to the chosen cutoff point is shown in (Figure 2).

DISCUSSION

This case-control study was carried out to support or refute the relationship of some occlusal factors with the presence of NCCLs in a population of young people (dental students). The homogeneity of subject origin, the average age of the sample (22.55 years, with the largest number of participants in the range of 21-23 years), and the fact that a matching strategy for cases and controls has not been used can be limitations. In any case, the selected sample of dentistry students may not be representative of the general population, so the translation of the results to the general population for their age range or for another range must be done with reservation. However, the use of nonrepresentative samples such as dental students, members of the military, or patients of dental clinics is frequent in studies of this type.[15,16,19-21] Moreover, most cross-sectional, case-control, and *in situ* studies consider age to represent a risk factor, be an important factor, or have a significant association with the presence and pro-

Table 4: *Variables of the Multivariate Logistic Regression Model*

Model Variable	OR	Standard Error	95% CI-OR	*p* Value
Protrusive interferences	1.93	0.51	1.12-3.22	0.017
Self-reported bruxism	1.72	0.47	1.01-2.96	0.048
Age	1.16	0.06	1.04-1.29	0.008
Subject with attrition	1.07	0.03	1.01-1.13	0.014

Abbreviations: CI, confidence interval; OR, odds ratio.

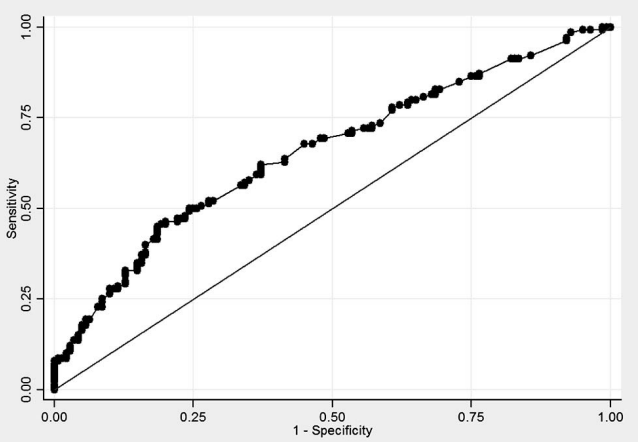

Figure 1. *ROC curve of the logistic regression model. Area under ROC curve = 0.67; Corrected classified: 61.43%; Sensitivity: 60.71% Specificity: 67.41%.*

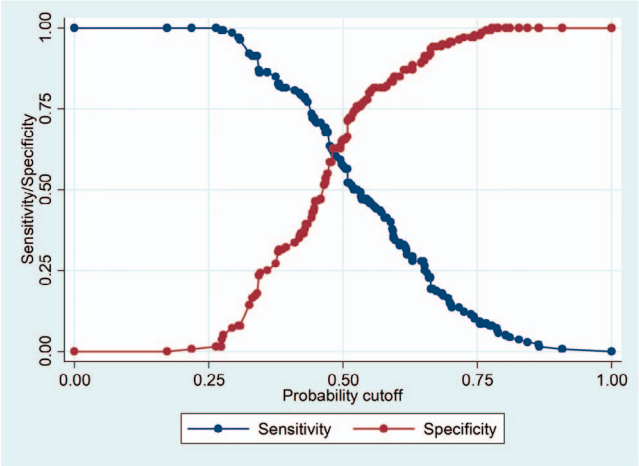

Figure 2. *Behavior of the sensitivity and specificity according to the chosen cutoff point.*

gression of NCCLs, with greater prevalence as age increases.[1-4,15,16,18,19,39,40] Thus, despite the variability of the different studies in relation to the selection and sample size, age groups, and other biases, the importance of age is based not only on data from recent studies,[4,16,19] which report high percentages of NCCLs in young adults from 20 to 45 years old, from 4% to 58.7%, and from 31.6% to 81.3% in the oldest age group of other studies,[1-3,15,18] but also on the recording of higher ORs in the older groups vs the younger ones[1,2] (8.1 in the group of patients 50-59 years of age and 2.3 in the group of patients 30-39 years vs those 20-29 years[1]; 2.45 in the group of patients 65-74 years old vs OR of 1 in the group aged 35-44 years[2]) or with a value of 1.1 in a multivariate analysis[16] very similar to the 1.16 of the predictive model of the present study. All of this is due to a longer time of exposure to possible risk factors, intrinsic and extrinsic, and also to changes in the cervical region of the teeth with a greater probability of gingival recession and greater exposure of the CEJ and cementum.

Although some studies do not find any such relationship of age with NCCLs,[35,41] nor with the depth of the lesions,[5] the data of the predictive model of the present study, even with the small age range of participants (18-29 years), support the influence of age on the presence of NCCLs and the idea that the onset can occur at very young ages. In addition, the results support the importance of some occlusal factors and bruxism for the onset of NCCLs despite the short period of time that may have elapsed in this sample from the presence of these factors and the registration of the NCCLs. Likewise, data reveal that bruxism and all those occlusal factors that have been shown to be risk factors (protrusive interferences and attrition), or simply to have a significant association in the univariate analysis, can transmit early stress to the CEJ, thereby initiating an NCCL, without the need for the concurrence of other factors or situations that increase the frequency and severity of the lesions at an older age. These factors and situations include changes in the composition and microstructure of enamel and dentin, more frequent crazing and vertical microfractures in older enamel, greater gingival recession and bone loss with greater root surface and cementum exposed, longstanding exposure to factors generating cervical stress, and longer time of action of other factors not related to occlusion.

The data of this case-control study show that self-reported bruxism is a risk factor for the development of NCCLs. These lesions are significantly more frequent (2.63 times) in subjects who clench and grind their teeth than in those who do not normally do so. The possible contribution of parafunctional activity has been reported in previous studies of different design with contradictory results, supporting[2,7,18,20,29,30,32,42] or not[1,16,31] its influence. Bruxism was a variable in Bader's old case-control study model[7]; in a study of young adults (average age of 28.37 years) diagnosed as sleep bruxers, NCCLs were significantly more frequent than in the control group[30] and significantly more numerous in the laterotrusive grinding pattern involving incisors, canines, premolars, and molars of 51 sleep bruxers.[42] Comparing 102 self-reported adult bruxers and nonbruxers, a significant association was found between bruxism and attrition, abfraction, and occlusal pits,[12] while in a prospective 5-year study,

the progression of NCCLs was not significantly associated with self-reported bruxism.[32] Some prevalence studies with logistic regression analysis indicate bruxism as a risk factor (OR=1.37).[2] Other studies report in older patients (65- to 74-year-olds) a significantly higher average of teeth with NCCLs in bruxers compared with nonbruxers,[18] and in younger patients (age range 19-58 years), NCCLs were significantly associated with tooth clenching.[20] However, other studies did not find an association with bruxism in a sample of 1023 subjects aged 20 to 69 years,[1] in 159 self-defense force officials with an average age of 36.2 years,[16] or in bruxism diagnosed by flat occlusal morphology.[31]

On the other hand, it is common for dentists to identify bruxism by the presence of occlusal wear facets. Although these may indicate a history of grinding, it should be recognized that not all occlusal wear is caused by bruxism, since there are other factors with similar or different action mechanisms that lead to tooth tissue loss. The occlusal wear facets may be the result of the elimination of occlusal disturbances or the result of other attrition factors. In this respect, the literature is also inconclusive when associating occlusal wear and NCCLs, with previous studies that support it[3,16,19,31,40,41] and others that do not.[5,6,32,36] Regardless of the design of the study, not having registered the variables using a single- or double-blind method may have influenced these results. A single nonblinded examiner, in the face of an NCCL, may be more careful in the occlusion examination than when there is no lesion, thus trying to confirm his or her suspicion. Only one study of those cited checked this bias.[36] Nevertheless, the present study data do not lend a great deal of support to occlusal wear (attrition) as a risk factor for the presence of NCCLs (at the significance limit in univariate regression and OR=1.07 in the multivariate logistic regression model).

In grinding and clenching situations (bruxism), occlusal contacts may be traumatic because they induce greater occlusal load, are of longer duration, and have a greater horizontal component. It has been reported that bruxers are able to apply occlusal loads that are five to seven times greater than normal subjects and with a longer tooth contact time (30 minutes) during a 24-hour period than nonbruxers (10 minutes). Moreover, during grinding, an eccentric occlusal load occurs between sloped cusps that causes greater cuspal deflection, especially at the end of the movement, compared with a centric occlusion load. The cuspal deflection was reported to be 200-400 μm in lateral movement and 20 μm in centric occlusion.[43] All of this can contribute to an increase in tensile, compression, and shear stresses in the cervical region of the teeth, favoring the development of NCCLs.

On the other hand, it remains to be clinically demonstrated whether the occlusal characteristics that can transmit stress to the CEJ play an important role as risk factors for the presence and development of NCCLs.[8,9] The results of this study support this statement. Of all the variables related to occlusion, only interference in the protrusive and lateral excursive movements (in particular on the nonworking side) are risk factors for the presence of NCCLs in the univariate logistic regression analysis and only protrusive interferences in combination with bruxism, age, and attrition in the multivariate logistic regression model. The increased risk of the presence of NCCLs in patients with protrusive interferences is not shared by the results of previous studies,[3,17,36] nor is the increased risk of NCCLs due to interferences on the nonworking side during lateral movements in agreement with a tooth-paired case-control study that reported a significant association with premature contacts or protrusive and working-side contacts.[17] Nor does it agree with the protective effect attributed to the presence of a non–working-side contact[7] or with the low percentage (20%) of teeth with NCCLs and non–working-side interferences reported by Miller.[31] The greater distance from a contact on the nonworking side to the pivoting condyle, with a greater lever effect and greater moment of rotation, can generate and transmit more stress to the tooth, thus favoring the presence of NCCLs compared with a contact on the working side. Even so, some studies report a significant association with contacts on the working side.[17] However, unlike studies that support the risk of a particular occlusal guidance scheme (canine or group function) in the etiology of NCCLs,[3,7,19,31,34,41,44] this study does not share this idea, being in greater agreement with those that do not report a significant association.[15,30,32,33,36,45]

In this study, the best predictive model indicated that occlusal disorders such as protrusive interferences and attrition (occlusal wear) in combination with self-referred bruxism and age are the risk factors for the presence of NCCLs. However, this model has an area under the ROC curve of 0.667, a positive predictive value of 62.50%, and a classification power of 61.43%. It is a poor determinant model that shows that occlusal factors alone are not sufficient to explain the presence of NCCLs in the

age range of the study. Other factors must be incorporated into the model to increase its predictive capacity. Therefore, the results support the multifactorial etiology of NCCLs. The term *biotribocorrosion* has been suggested in an attempt to combine all possible mechanisms of action that may play a part in the development of NCCLs, either through wear and/or chemical, electrochemical, or piezoelectric degradation. The cervical stress concentration of occlusal origin may act synergistically with other factors having an abrasive or local pH-lowering action to induce NCCLs.

The combination of mechanical stress and low pH has been shown to accelerate the loss of dentin[46] and increase subsurface demineralization with static loading[47]; in addition, the combination of erosion and abrasion due to brushing increases tooth wear.[48-50] In one of the few available case-control studies, Bader and others[7] found a model that, in addition to diet (fruit juices), low salivary buffering capacity, and brushing factors (brushing hard, more than three times a day) as risk factors, also included occlusal alterations (right canine guidance) and bruxism. In another study, whose unit of analysis was the teeth, and in which a univariate analysis was performed, the premature contacts and contacts on the working side represented the significant differences.[17]

In keeping with the aforementioned long-term clinical trials, including several age groups and controlling confounders and effect modifiers are necessary to establish a causal relationship between occlusal risk factors and the onset and progression of NCCLs. It is also necessary for dentists to understand the importance of the etiology and risk factors of NCCLs, but not on the basis of their experience or on theories unsupported by high-level clinical evidence. Given the limited scientific evidence of occlusion in the development of NCCLs, irreversible treatments such as occlusal adjustment should be avoided.[22] In addition, patients should be informed of the clinical consequences, prevention methods, and the need to control the risk factors for these lesions, as well as the combined effect of several of these factors, which may favor a greater presence and progression of NCCLs compared with a single risk factor.

In addition to the possible limitation of age, the present study is not free of other limitations. In a case-control design, the cause (exposure) and effect data are post hoc, with the exposure data being recorded at the same time as the effect, often indirectly. Therefore, the relationship between the independent variables may not reflect conditions at the time of the onset of the NCCLs, which is a limitation. A score of 2 or higher of the Tooth Wear Index of Smith and Knight[38] was used in this study. This index is frequently used to evaluate cervical wear in NCCLs.[2,4,5,16,18] For the cervical region of a tooth, a score of 2 (defect less than 1-mm deep) represents well-established wear compared with a score of 0 (no change of contour) or a score of 1 (minimal loss of contour), in which there is no wear or, at most, loss of enamel surface characteristics and is therefore difficult to detect visually or by the periodontal probe. This study aimed to register only well-established lesions with a minimum score of 2. This can be a limitation since examiners may have tried to register possible initial level 1 injuries in young people. The self-reported questionnaires are not the ideal method for recording bruxism because of possible imprecision in the patients' responses, but they are used in all studies related to NCCLs. Premature contacts that are often clinically and didactically important have not been recorded in this study, and this may be a limitation since a significant association has been noted in some studies[15,17] but not in others.[30,35]

CONCLUSIONS

According to the results obtained and taking into account the limitations of studies of this type, the following conclusions can be deduced:

1. There is no significant relationship between most occlusal disturbances and the presence of NCCLs. Only protrusive and lateral interferences, especially on the nonworking side, are statistically significant.
2. The predictive model includes protrusive interferences, bruxism, age, and attrition as risk factors but with only 61.43% correct classification. Therefore, the occlusal factors alone do not appear to be sufficient to explain the presence of NCCLs.
3. The young age, narrow age range, and good health of the subjects; the short period of time of actuation of the risk factors; and the possible nonrepresentability of the sample of the general population are limitations that make the transfer of the results to the general population more difficult.
4. The influence of occlusal factors corresponds to the beginning of the NCCL process since time is one of the primary factors in the progression of NCCLs, and only a short period has passed in the sample under study.

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Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the School of Dentistry at the University of Oviedo in Spain.

Conflict of Interest

The authors of this article certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

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