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Abfraction Theory: Controversy Analysis, Scoping Review

Mario Dioguardi[1] · Francesca Spirito[1] · Giovanna Iacovelli[1] · Diego Sovereto[1] · Enrica Laneve[1] · Giorgia Apollonia Caloro[2] · Andrea Ballini[1] · Angelo Martella[3] · Lorenzo Lo Muzio[1]

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Abstract

Purpose of review The aim of this review was to describe in detail the aetiological events involved in the abfraction phenomenon, examining the action of irregular occlusal forces, analysing the evidence supporting this aetiological hypothesis, and highlighting the controversies surrounding this theory.

Recent findings Noncarious cervical lesions (NCCLs) are the result of two widely accepted pathological mechanisms: erosion and abrasion. These lesions generally affect adults after the age of 30, and approximately 10–40% of adults in this age bracket have this condition. Premolars are the primary teeth affected by NCCLs. Characteristic symptoms include progressive and ongoing loss of mineralized tissue, primarily on the buccal surfaces of collars. As the dentine is exposed, the tooth becomes increasingly sensitive. Over time, the lesion tends to deepen towards the dental pulp, and the dental crown or pulpitis may fracture. Both abrasion and erosion alone cannot fully explain all types of NCCLs. For some lesions, this difference appears to be related to an aetiopathological mechanism defined as abfraction, which combines the aetiological events of erosion and abrasion with the application of irregular occlusal loads along the occlusal surfaces of dental crowns. This study was conducted by following the PRISMA protocol guidelines for scoping reviews, and the protocol was registered on INPLASY prior to execution. The studies were identified through literature searches in the PubMed and Scopus databases using the following keywords: "abfraction" and "NCCL". The risk of bias was assessed using ROBINS-I.

Summary The search led to the inclusion of only 6 studies out of a total of 1449 identified articles. The analysis of these studies, which correlated the progression of NCCLs to the forces applied to the teeth, did not provide sufficient evidence to confirm or refute the aetiological role of occlusal loads in the onset of abfractions. However, clues emerged that would require further confirmation through prospective longitudinal studies, which must consider the inclusion of other aetiological mechanisms, such as abrasion and erosion.

Keywords Noncarious cervical lesions · Dental erosion · Dental abrasion · Abfraction · Conservative · Caries

✉ Mario Dioguardi
mario.dioguardi@unifg.it

Francesca Spirito
spirito.francesca97@gmail.com

Giovanna Iacovelli
giovanna_iacovelli.559712@unifg.it

Diego Sovereto
diego_sovereto.546709@unifg.it

Enrica Laneve
enrica.laneve@unifg.it

Giorgia Apollonia Caloro
giorgiacaloro1983@hotmail.it

Andrea Ballini
andrea.ballini@unifg.it

Angelo Martella
angelo.martella@unisalento.it

Lorenzo Lo Muzio
lorenzo.lomuzio@unifg.it

[1] Department of Clinical and Experimental Medicine, University of Foggia, Via Rovelli 50, 71122 Foggia, Italy

[2] Unità Operativa Nefrologia E Dialisi, Presidio Ospedaliero Scorrano, ASL (Azienda Sanitaria Locale) Lecce, Via Giuseppina Delli Ponti, 73020 Scorrano, Italy

[3] DataLab, Department of Engineering for Innovation, University of Salento, Lecce, Italy

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Introduction

The main cause of the destruction of mineralized dental tissue is dental caries, which affects approximately 90% of the adult population and 50% of the child population [1, 2]. However, carious lesions are not the only cause of loss of mineralized tooth tissues. Among the types of lesions, we have observed that NCCLs mainly affect the crown cervical third region [3].

NCCLs are lesions that originate from 2 widely accepted pathological mechanisms—erosion and abrasion—similar to friction lesions; however, these lesions affect dental occlusal surfaces [4•].

Erosion processes are determined by a generally acidic chemical action that results in tooth mineralized surface erosion, and abrasion processes cause wear of dental hard tissues through extrinsic mechanical action, thus determining the destruction of enamel prisms (brushing trauma) [5••].

NCCLs are prevalent in approximately 10–40% of the population [6], as reported by Black, who analysed the Illinois population [7]. These lesions are generally found in adults after the age of 30, and the teeth involved are generally premolars. The symptomatology concerns the progressive and continued loss of mineralized tissue over time, mainly at the collar vestibular surface level. This loss is perceived by the patient as the presence of a step, occasionally with clear margins and gingival recessions.

Following the exposure of dentine, the tooth becomes increasingly sensitive; in fact, patients report an increase in sensitivity to heat and cold following the ingestion of generally cold drinks and foods, as well as while performing brushing manoeuvres, which leads patients to consult a dentist for the resolution of symptoms. Progressively, the lesion tends to expand in the direction of the dental pulp, accompanied by a dental crown fracture or pulpitis [8].

Abrasion and erosion alone cannot explain all the types of NCCLs, and for some lesions, they seem to be related to the aetiopathological mechanism of abfraction. Abfraction combines the aetiological events that occur in erosion or abrasion with the irregular and continued occlusal loads over time along the dental crown vestibular surfaces, generally causing NCCLs with clear margins. Specifically, when a tooth is overloaded in a nonaxial direction, the stress is concentrated on the vulnerable tooth cervical area, causing microfractures in hydroxyapatite crystals and eventually wedge-shaped lesions(8).

Only one systematic literature review has been conducted specifically on abfractions. In 2017, Duangthip et al. [9] concluded that the majority of scholars have reported an association between occlusal stress and noncarious cervical lesions. However, upon analysing this review in detail, some controversies emerge, starting from the type of lesion that is more generally identified as an NCCL, despite the title; hypothetically, this lesion should have only an erosive or abrasive aetiology (mainly brushing trauma), and its clinical characteristics should be different from those of abfraction. Therefore, an analysis of the studies should be performed only on a specific subgroup of lesions, differentiating them a priori from those cases in which erosion and abrasion aetiologies are clearly identifiable. Furthermore, Duanghthip et al. [9] clearly reported that there are no clinical studies linking occlusal stresses and NCCLs; moreover, among the 38 laboratory studies performed, only 9 authors suggested that stress is a mechanism for NCCLs, although the majority of scholars agreed that occlusal stress is concentrated at the tooth cervical surface.

Therefore, conducting a longitudinal clinical study, specifically on abfractions, is difficult; in particular, this difficulty depends on the hypothetical mechanism of action, which takes a long time to exert its effects on cervical areas [9].

The aim of this scoping review was to comprehensively describe the aetiological events implicated in the abfraction phenomenon, particularly by relating irregular occlusal forces, analysing the evidence supporting this aetiological hypothesis and highlighting the controversies that characterize this theory.

Methods

This study was conducted on the basis of the PRISMA protocol for scoping reviews: the scoping review was written following the PRISMA-ScR checklist (PRISMA Extension for Scoping Reviews) as reported by Tricco et al.[10]. The scoping review protocol was registered before its execution on the International Platform of Registered Systematic Review and Meta-analysis Protocols (INPLASY), with INPLASY registration numbers INPLASY202370052 and https://doi.org/10.37766/inplasy2023.7.0052.

The study was developed on the population, intervention, control, and outcome (PICO) questions: Population (patients with lesions attributable to NCCLs), Intervention (patients who presented abnormal or nonaxial occlusal stresses on teeth), Comparison (patients who did not present abnormal or nonaxial occlusal stresses on teeth) and Outcome (the presence of NCCLs).

The PICO questionnaire was formulated as follows. (1) What is the real impact of abnormal or nonaxial occlusal stresses on the onset of NCCL? (2) Can the aetiology of these lesions be ascribed to the aetiopathological mechanism abfraction? After the first set of records was identified in the PubMed and Scopus databases and the first set of

manuscripts was selected from other sources and bibliographic references, the selection of potential eligible records was qualitatively evaluated to identify the NCCLs possibly caused by abfraction.

Eligibility Criteria

The studies included were randomized clinical trials (RCTs), prospective studies and retrospective studies, which evaluated the presence of NCCLs, ascribing them to an aetiopathological mechanism of abfraction.

All potentially eligible articles were ultimately subjected to a full-text analysis to verify their use for qualitative and quantitative analyses.

The following criteria were applied in the evaluation of the papers:

Inclusion: All clinical trials evaluating NCCLs relative to abfraction.

Exclusion*:* In vitro studies, laboratory studies, case reports, case series, review meta-analyses, studies that did not present an abstract in English, and clinical studies that did not separate reported data on carious cervical lesions.

Information Sources

Studies were identified through bibliographic searches of the PubMed and Scopus databases.

In addition, a grey literature search was performed on Google Scholar and OpenGray (DANS EASY Archive); potentially eligible articles were identified among references from literature reviews on the topic of abfraction.

The research was conducted between June 1, 2023, and July 7, 2023.

Search

The authors responsible for researching the studies used the following keywords in the databases: abfraction and NCCL. The keywords used on PubMed were as follows:

Search: abfraction OR NCCL OR noncarious cervical lesions.

Selection of Sources of Evidence

A search for suitable reports was conducted by 2 reviewers (M.D. and D.S.), and a 3rd reviewer (G.I.) was tasked with choosing whether to include studies in conflicting situations.

The 2 reviewers, after they agreed on the eligibility criteria, the databases, and the keywords to be used, independently searched for articles and reported the number obtained for each keyword and bank in the word data table.

Manuscripts or reports that were found to be duplicates from the various databases were removed from the final count using EndNote 9 software (Philadelphia, PA, USA).

Other duplicates were then manually deleted by the authors after the screening phase (studies with references from databases or systematic reviews in which it was not possible to automatically upload the references to EndNote).

The 2 reviewers subsequently compared the included manuscripts and discussed the conflicting reports to determine which records should be included.

Data Charting Process, Data Items, Synthesis of Results

The characteristics and type of data to be extracted from the studies were decided jointly by the 2 reviewers immediately after the studies were selected. The data used were as follows: the first author, the year of publication, the bibliographic reference, the type of study, the number of patients, the sex distribution, the number of lesions present in the different groups and the main results and conclusions of the study. The data were extracted independently by the 2 reviewers in 2 different tables and subsequently compared, and they are reported in the 3rd table by the 3rd reviewer, who verified the accuracy of the data entry.

Results

Results of Sources of Evidence

The research questions that guided the selection of studies were as follows. What is the real impact of abnormal or nonaxial occlusal stresses on the onset of NCCLs? Can the aetiology of these lesions be ascribed to the aetiopathological mechanism of abfraction?

The research phase was conducted by consulting and extracting bibliographic references from two databases, SCOPUS (638 records) and PubMed (811 records), providing 1449 records. Duplicates were removed using software (EndNote X8), while duplicates not identified by the software or whose bibliographic references were not uploaded to EndNote were manually identified and removed, resulting in a total of 948 records.

After the articles were selected based on the reading of the title and the abstract, 174 potentially eligible articles were identified, and at the end of the selection, 6 studies were included in the qualitative evaluation. A further search was performed on the grey literature (Google Scholar and Open Grey) and on previous systematic reviews; additional studies were not included in the review (Fig. 1).

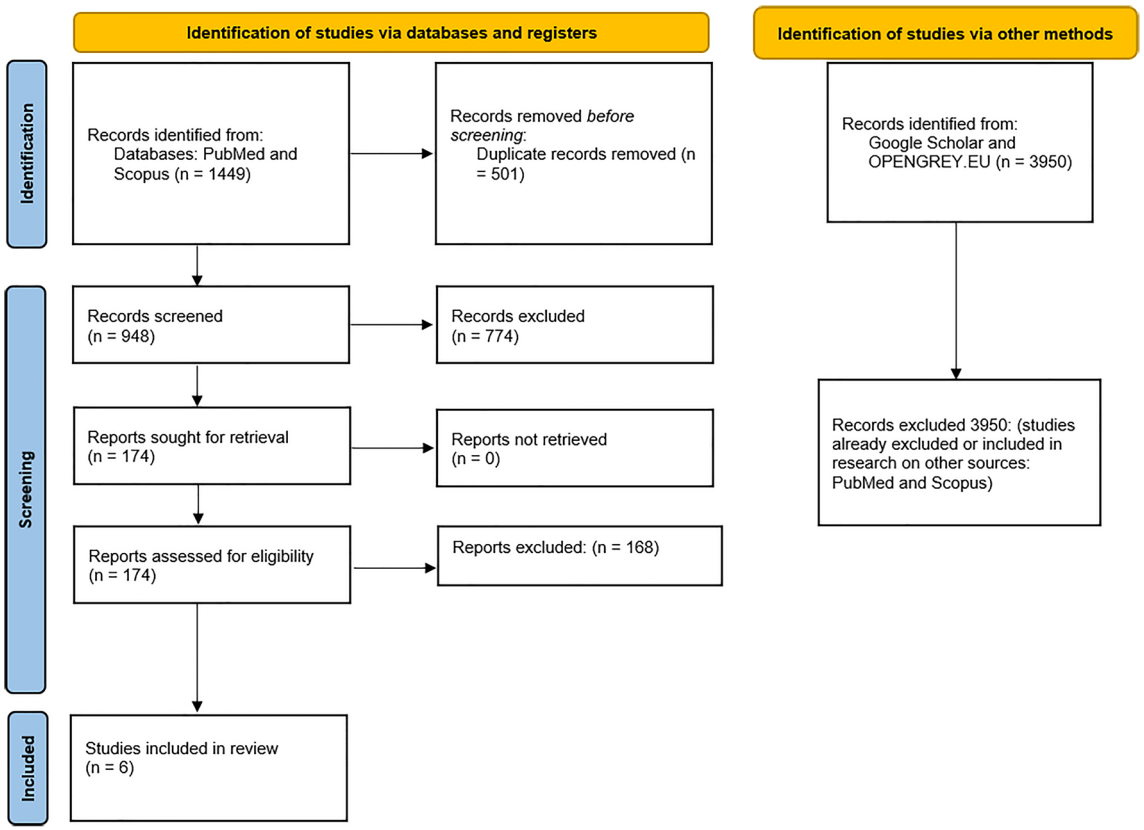

Fig. 1 Entire selection and screening procedure described in the PRISMA flowchart

Data Characteristics

The studies included in the scoping review were Wood et al., 2009 [11], Rusu Olaru et al., 2019 [12], Haralur et al., 2019 [13], Sawlani et al., 2016 [14], Antonelli et al., 2013 [15] and Werneck et al., 2023 [16••].

The extracted data are presented in a single table (Table 1), which includes data regarding the first author, the country of the study, the type of study, the total number of patients, the mean age or range, the number of teeth or NCCLs, the possible follow-up period, the methods of evaluation and measurement of the occlusal forces applied by the patients and the main results obtained in line with the scoping review.

The typology of the studies was heterogeneous; in fact, there were control cases, an RCT, a prospective cohort study and 3 cross-sectional observational clinical studies. A total of 368 patients were included, while approximately 389 patients were diagnosed with NCCLs; furthermore, occlusal forces were measured via T-Scanning in only 3 studies. In the longitudinal studies, the follow-up ranged from 6 months to 5 years.

Discussion

The present scoping review was performed to determine the relationship between irregular occlusal force loads and the onset of NCCLs. This relationship was obtained to determine the impact of nonaxial occlusal forces on determining which type of lesion was not solely attributable to erosion or abrasion but was linked to the aetiopathological mechanism of abfraction.

Abfraction is not an evident biophysical phenomenon, but it is considered in this review as a theoretical process in which occlusal forces cause microfractures in the cervical tissue of a tooth, predisposing it to erosion and abrasion and resulting in NCCLs; however, this theory has not yet been demonstrated and presents several points of controversy that will be further explored.

To our knowledge, this is the first review performed on this specific topic to date, representing a preliminary draft that foresees research on this topic in an extensive systematic review and/or meta-analysis in the future. The scoping review involved 6 articles with a total of 368 patients, 389 of whom had NCCLs.

Table 1 Characteristics of the studies included in the scoping review; UK: United Kingdom; RCT: randomized controlled trial; PS: prospective study; CC: case control; CS: clinical study; F: female; M: male; y: years; DS: deviation standard; N: number, m: months; NCCLs: noncarious cervical lesions; and \: data not available or not present

First author, data	Country	Study design	Population (F, M)	Mean age (y), DS, age range (y)	N. teeth	Follow-up	Evaluation lesions	Results
Wood et al., 2009 [11]	UK	RCT	39	51 ± 9.1 y, 35–70	62 (31 patients)	6, 18 and 30 m	Impression	The excursive occlusal load did not affect the rate of progression
Rusu Olaru et al.; 2019 [12]	Romania	CS	102 (47, 55)	20–80	135 NCCLs	\	Questionnaire	Abfraction injuries are related to parafunctions
Haralur et al., 2019[13]	Saudi Arabia	CS	100	\	50 NCCLs	\	Questionnaire, T-Scan	Brushing correlated with the development of NCCLs. The NCCL group had extended mean occlusion time and disocclusion time in all eccentric mandibular movements
Sawlani et al., 2016 [14]	USA	PS	29 (14, 15)	60.3 y	83 teeth	1, 2 and 5 y	Impression, T-Scan, questionnaire	NCCL progression was correlated with occlusal stress. No correlation was found between NCCL progression and the consumption of a highly acidic diet and toothbrushing technique/function
Antonelli, et al., 2013[15]	USA	CS	20	60% of patients were between the ages of 46 and 55; 15% were 35–45 and 25% were age 57–66 years old	227 teeth 51 NCCLs	\	Clinical examination during first appointment	22.5% of all teeth that were contacted in working excursions exhibited NCCLs; only 2.1% of the teeth on the canine guided sides exhibited NCCLs, which were found exclusively in canines
Werneck et al., 2023 [16••]	Brazil	CC	78 (63,15)	20–59	39 patients con NCCLS	\	T-Scan, questionnaire	An association was found between the presence of NCCLs and occlusal forces

The included studies, which have exclusively been focused on in vivo studies correlating occlusal forces with the presence of NCCLs, are highly heterogeneous in study design, purpose and results. In fact, two studies investigating the progression of NCCLs [11, 14] have reported data with divergent results. Conclusions about the aetiological causes of abfraction based on these studies can introduce bias due to a partial view of the data. Moreover, the methodology for evaluating occlusal forces is consistent in only 3 studies (T-Scan) (Table 1). While remaining faithful to the protocol of a predetermined scoping review, the presence of this heterogeneity allows for a relatively broad discussion, including points of controversy highlighted by the scoping review. This heterogeneity does not exclude studies that, although not in vivo, would be crucial for analysing controversies and refuting or affirming the possible aetiological connection.

Furthermore, it is considered impossible to carry out a systematic review with meta-analysis due to the lack of available data.

The controversies surrounding the nature of non-carious cervical lesions have persisted since the inception of the terminology. In the scientific literature, there is ambiguity concerning the use of certain terms and acronyms aimed at identifying the clinical conditions and pathological processes considered in the formation of these lesions.

According to the International Classification of Diseases Codes (ICD) of 2023, the classification of hard tissue loss of the tooth includes the following codes: K03.0 for excessive attrition of teeth, K03.1 for abrasion of teeth, and K03.2 for erosion of teeth [17••].

Following a meeting between the European Organization for Dental Caries Research and the Cariology Research Group of the International Association for Dental Research (IADR), which aimed to define the terminology of erosive tooth wear and dental caries, certain terms emerged and were widely accepted anonymously by all participants for defining various clinical situations [18].

The terms most utilized in the literature to describe clinical conditions are 'tooth wear' and 'erosive tooth wear'. The former is defined as the cumulative surface loss of mineralized dental substances due to physical or physicochemical processes (attrition, dental erosion, and abrasion), excluding pathologies caused by cavities, traumas, and resorptions. Moreover, 'erosive tooth wear' includes clinical situations in which the loss of mineralized hard tissue results from dental erosion. Dental erosion is characterized by the chemical loss of mineralized dental substances caused by exposure to acids not derived from bacteria. A loss due to a physical force exerted by contact with the antagonistic tooth is referred to as attrition. Conversely, if the cause is an object other than a tooth, the process is termed dental abrasion.

The use of the term 'abfraction' has been discouraged, and its use should indicate the pathological loss of dental substances caused by biomechanical loading forces leading to the flexure and yielding of enamel and dentin in a position distant from the load [19]. This term was introduced in recent years by several authors to explain the wear of the cervical part of the tooth induced by occlusal loading, suggesting that it is caused by extrinsic mechanical stress during chewing or by malocclusion [18].

Recent guidelines have further advised against using the term 'abfraction', as there is a lack of data justifying a pathological process separate from the conditions previously described. Similarly, the term used in the literature to identify no carious cervical lesions, abbreviated as NCCL in this review, should be avoided [20•].

In 1907, Miller WD identified a series of aetiological causes underlying the loss of mineralized substances in the cervical regions of the tooth. The phenomena observed and objects under examination are abrasion from fine granules (the main cause provided by Miller is the use of the toothbrush with toothpastes with the presence of granules), chemical abrasion and chemical erosion from acids [21]; moreover, these same phenomena have been reported by Black in his work on operative dentistry in 1908 [7].

In addition, Black has provided as many as 8 possible reasons for cervical erosion (erosion from acids [22], erosion induced by formation defects during tooth development, erosion from alkaline substances, acid erosion from microorganisms [23], brushing erosion, erosion understood as resorption as occurs for deciduous teeth [24•], erosion caused by the secretion of salivary glands, and acid erosion from gout [25]).

However, only in the 1970s and 1980s did we begin to consider how some NCCLs might not be connected to erosion from acids or brushing trauma [26, 27].

The hypothesis of Lee and Eakle was formulated in 1984 [27] and expresses the view that the main aetiological cause of NCCLs (called cervical lesions by the authors [28]) is tensile stress from chewing and malocclusion, during which the local oral environment plays a secondary role in the dissolution of the hard structures of the tooth (Figs. 2 and 3).

Lee and Eakle proposed the theory that when occlusion is less than ideal, lateral forces cause the mineralized structures of the teeth to bend. The tensile stresses created during bending disrupt the chemical bonds of the crystalline structures of enamel and dentine [29]. Small molecules can cross crystals and prevent the re-establishment of chemical bonds. Consequently, the disrupted tooth structure is susceptible to loss by dissolution and abrasion, which results in the development of typical wedge-shaped lesions.

According to this hypothesis, cervical lesions should have consistent and typical characteristics:

1. The lesion should be at or near the fulcrum.

Fig. 2 The facial view of the molar shows the production of two separate cervical lesions, which subsequently converge as tensile stresses produce the fulcrum around each of the two buccal roots (78-year-old woman)

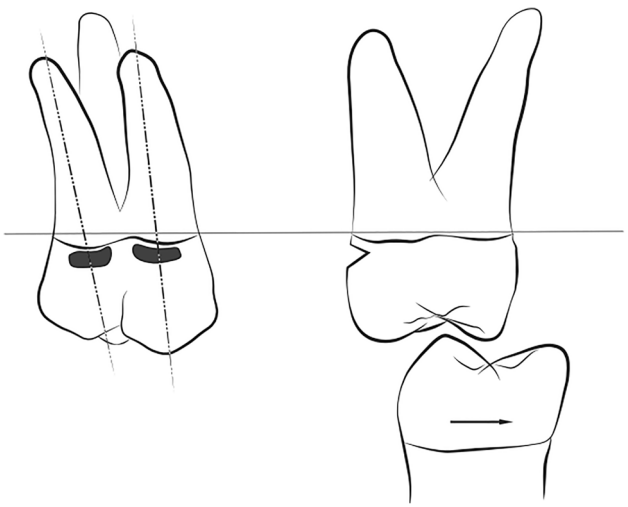

Fig. 3 Schematic reproduction of the mechanism of action proposed by Lee and Eakle in 1984 on the basis of the onset of multiple lesions on molars (drawing from Diego Sovereto based on figures from Lee and Eakle's study[27])

2. The region of maximum tensile stress concentration has a wedge-shaped volume with acute angles, which is one of the classic shapes of NCCLs.
3. The direction of the lateral force generating the tensile stress determines the location of the lesion. In the presence of 2 lateral forces, the combination of these forces generates a lesion that is the sum of 2 wedge-shaped lesions (Fig. 2).
4. The size of the lesion increases proportionally with the intensity and frequency of the applied traction force. When the lesion is farther from the fulcrum, the tensile force generated is greater, resulting in more extensive breakage of the tooth structure adjacent to the fulcrum.

Lee and Eakle's hypothesis is based on the information provided a decade earlier by Brady and Woody (1978) [26] on a population of 900 dentists, in which they identified the presence of compatible cervical lesions while describing NCCLs in 5.3% (48 patients) of the participants; the teeth most involved are premolars (64%).

Brady and Woody identified 2 distinct models of erosion with characteristic shapes. The first model reproduces an angular lesion with a flattened floor associated with deep lesions (68%), and the second model reproduces a rounded, small lesion without sharp internal angles or with reduced damage to mineralized tissue (32%).

Thus, cervical erosion can be attributed to two different aetiopathogenetic mechanisms:

1. a more common, angular and deep destructive process (compatible with current theories on abfraction)
2. a less severe and shallow process with more rounded shapes (phenomena attributable to erosion and abrasion), as hypothesized by Piotrowski [30]

The aetiology of abfractions has been discussed: it was discussed in 1887 (with Kirk calling it abrasion) [31], and the first aetiological cause widely investigated before non-axial occlusal forces were taken into consideration was the excessive brushing of the teeth, especially if the extrinsic movement was in a horizontal direction. This aetiological mechanism presented critical issues, which were previously exposed in 1974; in fact, Padbury and Ash (1974) reported that the rolling brushing technique generates more abrasion than the horizontal brushing technique [32].

Miller observed in 2003 how NCCLs develop on the teeth of patients with poor or inadequate oral hygiene or in areas that are difficult to reach with a toothbrush. Sometimes, these lesions present a vertical shape even if the patients brushed horizontally [33].

However, the term abfraction and its underlying mechanism are coined by Grippo in 1992, who defined this term as a pathological loss of tooth substance caused by biomechanical loading forces [34].

On the basis of the theory formulated by Grippo, masticatory forces determine anomalous and nonaxial occlusal loads, and the masticatory apparatus is known to develop three types of stresses on the tooth: compression, traction and shear (compressive stress is resistance to compression; tensile stress is resistance to stretching and elongation; and shear stress is resistance to twisting or sliding). His theory on abfraction stems first from his observations. Grippo noted that teeth that undergo an eccentric load present cervical lesions, while generally, periodontal teeth that exhibit mobility tend to not present NCCLs. This phenomenon may occur because mobility dissipates the resulting concentration of stress, while a periodontally healthy tooth(35), when placed

under occlusal load, tends to flex and fatigue with the formation of cervical erosions. He also observed how teeth with periodontal mobility present relatively mild NCCLs [34].

These findings partially confirm the findings of Miller, who considered abfraction to be the cause of 309 lesions in 2003. Miller reported the coexistence of NCCLs with occlusal wear facets in 94.5% of patients and found that the lack of canine disclusion (77.2%) is closely associated with the presence of abfractions. Furthermore, tooth mobility exists in only 1.9% of patients in accordance with the findings of Grippo [33].

Similarly, Mayhew and Martin tested 178 teeth exhibiting NCCLs and reported that 95% had functional wear facets, indicating a systematic relationship with the presence of NCCLs, while 64% had balance interference in lateral excursion; there were no significant associations between mobility and facets [34]. Correlations were noted in a study by Tomasik (2006), in which he established a relationship between lateral excursive contact of the teeth, bruxism[36•] and the formation of cervical lesions, highlighting a correlation between occlusal pathology and the presence of NCCLs [37] (Fig. 4).

These studies highlighted the effects of bruxism clenching and interference in lateral excursions [15] through the presence of wear facets, which are present in 95% of patients with NCCLs(36•). In a recent study by Rusu Olaru et al. (2019) [12], abfraction lesions were revealed not only in various stages of progression in elderly patients but also in young people who presented malocclusions with the transmission of paraxial occlusal forces.

Scholars analysing the forces applied to teeth via T-Scans in relation to NCCLs have reported data that are not in agreement with the clinical observations previously described. In fact, Werneck et al., 2023 [16••] conducted a case−control study of 78 patients and found no association between the presence of NCCLs and occlusal strength or other factors, such as brushing technique and deleterious habits. Haralur et al., 2019[13] considered dynamic occlusal parameters with both protrusive and lateral movements and identified an extended average occlusion and disocclusion time in all eccentric mandibular movements in the NCCL group, further suggesting that the use of a hard toothbrush is associated with the development of NCCLs.

Fig. 4 The presence of NCCLs was defined as follows: lower left first premolar and lower left first molar. The presence of 2 distinct lesions on the molar was noted as described by Lee and Eakle's study in the area corresponding to the 2 fulcrums; left first upper canine; and upper left first molar with lesions similar to the lower one. Note the absence of lesions on the left upper premolars, where the former is in the absence of an antagonist (48 year old man)

It is the opinion of the authors of this review (MD) that analysing and considering the simple occlusal force that is discharged on a tooth as a factor that leads to the formation of an NCCL in a tooth that has already had a lesion is equivalent to measuring the occlusal force that is applied on a tooth after it has fractured, not before. These measurements should be taken before the onset of the lesions and not once they have already been established; these considerations can partially justify the results of an absence of the studies conducted: a prospective longitudinal study should be performed that relates the load of occlusal forces in all eccentric mandibular movements with the onset of NCCLs starting from healthy teeth [38].

These findings support the findings of a 5-year prospective study conducted by Sawlani et al., 2016 [14] on the progression of NCCL severity. The rate of progression, understood as the total volume lost over 5 years, is 1.50 ± 0.92 mm(3)/year. The rate of progression of NCCLs is related to the mean occlusal stress and the relative occlusal force at the maximum intercuspidation position. No differences are observed in NCCL progression among participants with other factors, such as acidic food consumption, tooth brushing technique/rigour, or medical conditions causing acidic saliva or a saliva deficiency.

This latter progression study contrasts with the 2009 RCT study by Wood, in which the progression of NCCLs was measured in patients who had no interference in lateral movements and still experienced progression [11].

The theory of abfraction proposed can lead one to think that this phenomenon is mainly based on anomalous or non-axial occlusal loads that are discharged during noncentric movements, in which tension, mostly from the flexor, accumulates predominantly on the buccal surface in the cervical region [39]. However, many authors do not agree that the lesions attributed to the abfraction phenomenon have a single aetiological cause; instead, these lesions are caused by a combination of abrasion, erosion, and nonaxial occlusal forces.

According to the multifactorial aetiology of abfractions, there is indirect evidence from comparative studies between Native Americans (XI-XVI century) and modern human skulls. The data presented by the authors show that

there are no NCCLs in the skulls of Native Americans, while 9.6% of the teeth of modern skulls exhibit these lesions. Moreover, the level of occlusal wear of the teeth is greater in Native Americans. These data support that for NCCLs, there are multifactorial causes that have been introduced in the modern lifestyle, such as brushing of the teeth with the aid of toothpastes and a diet high in sugar [40]. These same observations have been conducted by a French research group on ancient and prehistoric skulls, comparing them with modern skulls. The percentage of lesions is approximately 4.55% of teeth in modern skulls and 0% in archaeological skulls [24•]. These lesions were stratified by skeletal age in the latter study to reduce age-related bias as a factor that may have influenced the incidence of the NCCLs, providing the same results in terms of significance; Regardless of how you want to interpret the numerical value of 0, it will always remain a 0 [40–48].

The theoretical model that is configured by analysing the scientific literature certainly favours a multifactorial aetiology for NCCls, especially for those caused by abfraction.

If the observed clinical observations suggest the involvement of nonaxial occlusal forces on the teeth as the main cause of the lesions caused by abfraction, the complete absence of wedge-shaped lesions in historical skulls before the introduction of toothbrushes and abrasive toothpastes suggests an abrasive-type aetiopathological mechanism in the onset of this condition [49]. In contrast, there is a very low percentage of NCCLs in teeth with mobility and a high percentage of NCCLs in patients with dental wear in the occlusal plane, especially in bruxist patients and in patients who present noncanine disclusion in lateral movements.

A study conducted in 2021 using scanning electron microscopy (SEM) by Worawongvasu [50] involving 10 premolars extracted from 10 patients with cervical lesions was conducted to clarify the role of abfraction as an aetiology of these lesions. Worawongvasu hypothesized that abfraction represents another possible aetiological cause that, involving occlusal forces, produces cervical cracks predisposing the surface to erosion and abrasion.

SEM analysis clearly revealed a pattern of microfractures in at least 4 teeth, wherein one tooth exhibits a horizontal microfracture and erosion processes, a second tooth displays an oblique microfracture and characteristic linear scratches indicative of abrasion from brushing, and third and fourth teeth show only ultrastructural evidence of microfracture associated with abrasion-induced scratches. The remaining 6 teeth do not present microfractures; instead, the SEM images display a characteristic erosive surface pattern. Worawongvasu asserts that, in at least one patient, there is ultrastructural evidence of a combination of microfracture and erosion, concluding that abfraction may play a role in the formation of NCCLs [50].

A limitation of this study is the small number of included teeth and patients and the lack of a clear connection to occlusal forces. The possible cause of microfractures might be attributed to forces applied during tooth extraction and subsequent dehydration.

A previous study conducted by Daley et al. in 2009 [51] on a canine and lower incisor with wedge-shaped lesions did not show SEM-derived evidence of microfractures attributable to abfraction but only to erosion. Therefore, histopathological evidence of abfraction has not been found.

The analysis of the included studies that related the progression of NCCLs to the forces applied to the teeth does not provide sufficient evidence to confirm or refute the aetiological cause of the occlusal load at the onset of the abfraction; however, these studies provide clues that must be confirmed with prospective long-term studies that must take into account the inclusion of other aetiological mechanisms, such as abrasion (tooth brushing) and erosion (acidic and sugary substances) mechanisms.

These clinical findings, some of which have yet to be fully verified and clarified, suggest that there is no single aetiological cause of abfraction injuries. Hypothesizing a mechanism in which one might consider that for the aetiological events leading to a wedge-shaped lesion with clear margins that must be established, at least two determining factors must coexist, one of which is the anomalous and nonaxial occlusal load that causes the mineralized tooth structure to flex in the area of the fulcrum, generating a breakage of the prismatic crystalline lattice[52]; this event alone is not capable of generating wedge-shaped lesions, but there must be concomitant action of a second mechanism, which can certainly be abrasive (brushing trauma) or erosive (an acidic or high-sugar diet)[53]. Only with the introduction of one of these two mechanisms can the presence of this type of injury be explained only stating at the end of the nineteenth century(54).

Conclusion

In conclusion, despite the existence of many studies that offer support for the aetiological role of occlusal loads in the onset of an abfraction, there is no decisive evidence. Instead, the existing evidence is contradictory.

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Declarations

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Conflict of Interest The authors declare no conflicts of interest.

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- • Of importance
- •• Of major importance

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