

The relationship between stress distribution and adhesive failure in non-carious cervical lesions (NCCL): a review

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ABSTRACT

Non-carious cervical lesions (NCCLs) are lesions observed in dental hard tissues and have a multifactorial etiology. It is believed that surface loss processes such as abrasion and erosion, together with the biomechanical effects caused by occlusal stress, play a role in the development of these lesions. The structural characteristics of the cervical region and the distribution of stress within this area influence both lesion formation and the success of restorative treatments. The aim of this review is to evaluate the relationship between the etiology of NCCLs, biomechanical effects, and mechanisms of adhesive failure and to outline clinical approaches and restorative strategies accordingly. Current findings suggest that stress accumulation in the cervical region may adversely affect the adhesive interface, leading to loss of retention and marginal breakdown. Consequently, to achieve successful outcomes in the treatment of NCCLs, it is necessary to evaluate biomechanical factors and clinical variables together and to adopt a personalized treatment approach.

Keywords: Non-carious cervical lesions, NCCL, biomechanical stress, adhesive failure, occlusal loading, restorative treatment

INTRODUCTION

Non-carious cervical lesions (NCCL) are lesions frequently encountered in clinical practice and are recognized as a significant oral health problem. These lesions are characterized by non-carious hard tissue loss in the cervical region of the tooth, at the level of the cemento-enamel junction (CEJ).¹ With increasing life expectancy, individuals are able to preserve their natural teeth for longer, which has led to NCCLs becoming a more frequently observed finding during clinical examinations.² These lesions not only result in permanent tissue loss but can also lead to clinical problems such as dentine hypersensitivity, changes in pulp vitality, and increased plaque retention. Clinically, NCCLs can present with various morphological appearances, including superficial, concave, notched, or wedge-shaped lesions.³

NCCLs are defined as multifactorial lesions in which surface loss processes such as abrasion and erosion interact with the biomechanical effects caused by occlusal stress.⁴ Furthermore, factors such as poor oral hygiene habits, parafunctional activities, low buffering capacity of saliva, and an acidic pH in the oral environment may also contribute to the formation of these lesions. The reduction in enamel thickness in the cervical region and the relatively weak enamel-dentin junction render this area more susceptible to stress and wear factors.⁵ However, there is still no consensus in the literature regarding which material is more suitable for NCCL restorations and when restorative treatment should be initiated. In particular, the

effect of occlusal stress distribution on the adhesive interface and its relationship with restoration failure has not been sufficiently elucidated. Therefore, the aim of this review is to evaluate the effect of stress distribution on adhesive failure in NCCL restorations and to discuss clinical approaches in line with the current literature.

THE ETIOLOGY AND BIOMECHANICAL BASIS OF NCCL

The accurate identification and differentiation of NCCLs is of great importance for treatment planning. A careful clinical assessment is required, particularly in early-stage lesions, to distinguish between different etiological factors.⁴

Attrition refers to physical wear observed as a result of contact between tooth surfaces during normal masticatory (functional) or habit-related (parafunctional) movements. This condition is generally observed on occlusal and approximal surfaces and may lead to an enlargement of the interproximal contact areas over time. In advanced cases, changes in occlusal relationships may also occur.⁴

Abrasion is defined as wear in dental hard tissues resulting from external mechanical forces.⁶ Incorrect brushing techniques, excessive pressure, the use of brushes with stiff bristles, and toothpastes with high abrasive properties play a significant role in this process. These lesions are typically sharp-edged and wedge-shaped.⁷

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Erosion is the dissolution of dental hard tissues resulting from a chemical process caused by acids, independent of bacterial influence. This process is accelerated particularly by the consumption of acidic foods and drinks, the reflux of stomach acid into the mouth (gastric reflux), and environments with low pH levels. Furthermore, it is suggested that the buffering capacity of the environment may be a more significant factor in the progression of erosion than the pH value alone.⁸

Abfraction, on the other hand, is associated with a concentration of stress in the cervical region of the tooth resulting from flexure caused by occlusal forces, particularly their oblique and lateral components. Lesions formed via this mechanism are typically wedge-shaped, with sharp internal angles, and tend to progress towards the CEJ.⁹

While it is known that the development of NCCL is multifactorial, it has been suggested in recent years that biomechanical factors also play a significant role. In particular, the distribution of stress on the tooth caused by occlusal forces can concentrate in the cervical region, potentially leading to tissue loss.¹⁰ From a biomechanical perspective, occlusal forces, particularly those in the lateral direction, lead to stress concentration in the cervical region of the tooth. This accumulation of stress can cause micro-level flexures in the cervical region, leading to weakening of the enamel and dentine structure and, over time, tissue loss. The reduction in enamel thickness and the weaker enamel-dentine junction in the cervical region make this area more susceptible to the effects of stress.¹¹ However, it is thought that the effect of repetitive loads, rather than the one-off impact of occlusal forces, plays a significant role in the development of NCCL. The stress and flexion generated in the cervical region as a result of occlusal loads can lead to the formation of microcracks in the enamel and dentine structure; over time, this can create a fatigue-like effect, resulting in tissue loss.¹²

MECHANISMS OF ADHESIVE FAILURE IN NCCL

The number of studies evaluating the clinical efficacy of universal adhesive systems has increased recently. The clinical performance of these systems is generally assessed through randomized controlled trials, and the retention of the restorative material is considered a key indicator of long-term success. However, parameters such as marginal degradation and marginal discoloration are also important criteria in assessing adhesive success in NCCL restorations.¹³

The morphological and histological structure of the cervical region plays a critical role in adhesive failure. Thinning of the enamel layer and changes in the structure of the enamel prisms in this region can adversely affect the quality of the adhesive bond. Furthermore, the fact that dentine frequently exhibits sclerotic characteristics and that the tubules are obstructed by mineral deposits can hinder the penetration of adhesive systems into the dentine, thereby reducing bond strength.¹⁴ In NCCL restorations, adhesive failure is predominantly associated with defects occurring at the bond interface. The inability of adhesive systems to provide sufficient infiltration into the dentine surface and the degradation of the hybrid layer over time can lead to a reduction in bond strength. Systematic reviews and meta-analyses incorporating randomized clinical trials evaluating the efficacy of adhesive strategies in NCCL restorations have shown no significant difference between

self-etch and etch-and-rinse approaches in terms of retention, marginal adaptation, and staining. However, it is stated that restoration failures most commonly manifest as a loss of retention and that this is associated with the weakening of the adhesive interface over time.¹⁵

Due to the cervical region's proximity to the gingiva, controlling moisture is difficult, which increases the risk of contamination during adhesive application and may adversely affect the quality of the bond. These circumstances pave the way for clinical failures, particularly marginal detachment, microleakage, and loss of retention.¹⁶

The long-term success of NCCL restorations remains limited, and the mechanism of failure has not yet been fully elucidated. Restoration performance depends on factors such as the material's elastic properties, the durability of the adhesive interface, and wear resistance; it has been demonstrated that these properties degrade over time. Furthermore, the higher incidence of marginal defects in the cervical region is associated with the biomechanical and biological characteristics of this area. It has been reported that restoration failure is a process resulting from the combined influence of numerous factors, including occlusal stress, the location of the lesion, the presence of sclerotic dentine, and material properties.

THE RELATIONSHIP BETWEEN STRESS DISTRIBUTION AND ADHESIVE FAILURE

In NCCLs, stress distribution is concentrated in the cervical region, particularly depending on the direction and magnitude of occlusal forces. Elastic deformation of the teeth under oblique forces leads to an increase in tensile stresses in the cervical region. Finite element analyses show that these stresses accumulate most around the enamel-dentin junction and that this region is biomechanically more sensitive. Furthermore, the direction and magnitude of the load, as well as tooth morphology, directly influence the distribution of stress, potentially increasing stress concentration in specific areas.¹⁷ The effect of stress distribution in NCCL restorations on adhesive failure is explained, in particular, by the changes in stress occurring at the bonding interface. It has been reported that stresses generated in the cervical region cause different deformations between the restoration and the tooth structure and that this mismatch leads to stress accumulation at the adhesive interface.^{18,19} This accumulation of stress causes the adhesive layer to remain under constant load and may lead to a reduction in bond strength over time. In particular, the difference in behavior between dental tissue and restorative materials, which possess different elastic properties, can increase stress concentration at the adhesive interface, thereby adversely affecting bond integrity.¹⁹ Long-term clinical follow-up studies have reported that NCCL progression is associated with occlusal stress and that lesion progression is more pronounced in teeth subjected to high occlusal loads. This suggests that stress may play a role not only in lesion formation but also in post-restoration adhesive failure.²⁰

Furthermore, the fact that the stress generated in this region is not merely static but exhibits a repetitive nature during functional and parafunctional movements may lead to the weakening of the adhesive bond through a fatigue-like process. This study explains how interface disruptions, which



initially occur at a microscopic level, progress over time to result in clinically observable loss of retention and marginal defects.⁴

In NCCL restorations, adhesive failure is not only related to material or technical factors but also to the dynamic effects of stress on the adhesive interface. This situation sets the stage for the adhesive bond to weaken over time, leading to clinical loss of retention and marginal deterioration.¹⁶

CLINICAL APPROACHES AND RESTORATIVE STRATEGIES

In the management of NCCLs, non-restorative approaches should be considered before proceeding to restorative treatment. Particularly in cases where dentine hypersensitivity is the primary concern, the use of desensitizing agents, fluoride varnishes, and products containing potassium nitrate can be effective in controlling symptoms. Furthermore, controlling the etiological factors can help slow the progression of the lesion, thereby delaying the need for restorative intervention.⁵

The clinical approach to the treatment of NCCLs should not be reduced solely to material selection. A successful restorative strategy must be determined by evaluating the depth and morphology of the lesion, the presence of dentine hypersensitivity, aesthetic expectations, occlusal loading, parafunctional habits, and the gingival margin. In particular, the presence of sclerotic dentine in the cervical region, high marginal stress, and the tendency of the adhesive interface to degrade over time make NCCL restorations more difficult to predict.¹⁶

In terms of the choice of restorative materials, there is no clear superiority between resin composites and glass ionomer-based materials. While glass ionomer-based materials offer advantages, particularly in cases where moisture control is difficult and the root surface is more extensively involved, resin composites have a wider range of applications due to their aesthetic and mechanical properties.^{21,22} However, marginal leakage issues with resin composites and the degradation of the adhesive over time are among the key factors limiting clinical success. Consequently, the choice of an adhesive system and application technique play a critical role in the long-term success of the restoration.²³

A three-year randomized clinical trial compared different adhesive strategies (universal adhesive, glass ionomer, and EDTA pretreatment). While similar success rates were achieved across all groups, it was reported that marginal defects were observed more frequently in resin composite restorations during the early period.²⁴

In a randomized clinical trial comparing flowable composite with nano-filled composite, it was reported that the restorations were applied over the NCCL and that both materials demonstrated similar clinical performance in the short term.²⁵ In a 3-year study comparing high-filler flowable composite with conventional composite, it was reported that retention rates were similar but that the flowable composite yielded better results in terms of marginal adaptation.²⁶

Current evidence regarding adhesive strategies indicates that there is no significant difference in clinical success between self-etch and etch-and-rinse approaches. In NCCL restorations using universal adhesive systems, no significant superiority has been found between different protocols in

terms of retention, marginal adaptation, and staining.²⁷⁻²⁹ However, the limited presence of enamel in the cervical region, the absence of macro-mechanical retention, and the highly sclerotic nature of dentine are significant factors that complicate adhesive bonding. Furthermore, the heterogeneous structure of the bonding surface may adversely affect hybrid layer formation.^{23,24} For this reason, it has been suggested that, in some cases, the application of phosphoric acid prior to self-etch adhesive systems may enhance restoration retention.³⁰ This situation indicates that, in the clinical decision-making process, product-based evaluation is more important than material classification.²³

In NCCL restorations, lesion morphology is also an important clinical variable. While stress concentration and increased tension at the adhesive interface are more pronounced in deep, wedge-shaped lesions, a more homogeneous stress distribution may be observed in superficial and broad lesions. This indicates that the success of a restoration depends not only on the material but also on the shape of the lesion.⁴

In NCCL cases accompanied by parafunctional habits, a restorative approach alone may not be sufficient. Occlusal adjustments and the use of a night guard (occlusal splint) to reduce occlusal stress may help to control the stresses arising in the cervical region. It has been reported that this approach may indirectly enhance the long-term success of restorations.¹⁷

In cases of NCCL presenting with gingival recession, restorative treatment and periodontal surgery may need to be planned in conjunction. In such situations, the restoration stabilizes the root surface, while periodontal surgery supports aesthetic and functional improvement. It has been reported that the combined approach yields more successful results, particularly in the aesthetic zone.³¹

CONCLUSION

Non-carious cervical lesions are complex lesions with a multifactorial nature in terms of their formation mechanism and clinical behavior and cannot be explained by a single etiological factor. Success in the restorative treatment of these lesions depends not only on the material or adhesive system used but also on the combined assessment of stress distribution, dentine properties, lesion morphology, and patient-related factors. The current literature indicates that there is no single material or adhesive strategy that can be universally regarded as superior in NCCL restorations. Therefore, the clinical approach must be based on individualized treatment planning rather than standard protocols. Consequently, to achieve successful and long-term clinical outcomes in the management of NCCLs, the lesion must be assessed not only from a restorative perspective but also in conjunction with its biomechanical and biological environment, and the treatment plan must be formulated accordingly.

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Peer Review Process

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REFERENCES

- Denucci GC, Stone S, Hara AT. Non-carious cervical lesions: a bibliometric analysis and future research trends. *J Dent.* 2024;148:105229. doi:10.1016/j.jdent.2024.105229
- Goodacre CJ, Roberts WE, Munoz CA. Noncarious cervical lesions: morphology and progression, prevalence, etiology, pathophysiology, and clinical guidelines for restoration. *J Prosthodont.* 2023;32(2):e1-e18. doi:10.1111/jopr.13585
- Bartlett DW, Shah P. A critical review of non-carious cervical (wear) lesions and the role of abfraction, erosion, and abrasion. *J Dent Res.* 2006;85(4):306-312. doi:10.1177/154405910608500405
- Grippio JO, Simring M, Coleman TA. Abfraction, abrasion, biocorrosion, and the enigma of noncarious cervical lesions: a 20-year perspective. *J Esthet Restor Dent.* 2012;24(1):10-23. doi:10.1111/j.1708-8240.2011.00487.x
- Lussi A, Schaffner M. Progression of and risk factors for dental erosion and wedge-shaped defects over a 6-year period. *Caries Res.* 2000;34(2):182-187. doi:10.1159/000016587
- Addy M, Shellis RP. Interaction between attrition, abrasion and erosion in tooth wear. *Monogr Oral Sci.* 2006;20:17-31. doi:10.1159/000093348
- Shellis RP, Addy M. The interactions between attrition, abrasion and erosion in tooth wear. *Monogr Oral Sci.* 2014;25:32-45. doi:10.1159/000359936
- Featherstone JDB, Lussi A. Understanding the chemistry of dental erosion. *Monogr Oral Sci.* 2006;20:66-76. doi:10.1159/000093351
- Romeed SA, Malik R, Dunne SM. Stress analysis of occlusal forces in canine teeth and their role in the development of non-carious cervical lesions: abfraction. *Int J Dent.* 2012;2012:234845. doi:10.1155/2012/234845
- Litonjua LA, Andreana S, Bush PJ, Tobias TS, Cohen RE. Noncarious cervical lesions and abfractions: a re-evaluation. *J Am Dent Assoc.* 2003;134(7):845-850. doi:10.14219/jada.archive.2003.0282
- Soares PV, Santos-Filho PCF, Soares CJ, et al. Non-carious cervical lesions: influence of morphology and load type on biomechanical behaviour of maxillary incisors. *Aust Dent J.* 2013;58(3):306-314. doi:10.1111/adj.12084
- Bansal S. Noncarious cervical lesions as abfraction: etiology, diagnosis, and treatment modalities. *J Oral Health Dent.* 2014;438:1-6.
- Mahn E, Rousson V, Heintze S. Meta-analysis of the influence of bonding parameters on the clinical outcome of tooth-colored cervical restorations. *J Adhes Dent.* 2015;17(5):391-403. doi:10.3290/j.jad.a35008
- Van Meerbeek B, Yoshihara K, Yoshida Y, Mine A, De Munck J, Van Landuyt KL. State of the art of self-etch adhesives. *Dent Mater.* 2011;27(1):17-28. doi:10.1016/j.dental.2010.10.023
- Doshi K, Nivedhitha MS, Solete P, et al. Effect of adhesive strategy of universal adhesives in non-carious cervical lesions: an updated systematic review and meta-analysis. *BDJ Open.* 2023;9(1):3. doi:10.1038/s41405-022-00124-6
- Pecie R, Krejci I, Garcia-Godoy F, Bortolotto T. Noncarious cervical lesions (NCCL)-a clinical concept based on the literature review. Part 2: restoration. *Am J Dent.* 2011;24(3):183-192.
- Soares PV, Grippo JO. Noncarious cervical lesions and occlusal stress. *Aust Dent J.* 2013;58(suppl 1):134-139. doi:10.1111/adj.12098
- Ichim I, Li Q, Loughran J, Swain MV, Kieser J. Restoration of non-carious cervical lesions. Part I. Modelling of restorative fracture. *Dent Mater.* 2007;23(12):1553-1561. doi:10.1016/j.dental.2007.02.003
- Ichim I, Schmidlin PR, Kieser JA, Swain MV. Mechanical evaluation of cervical glass-ionomer restorations: 3D finite element study. *J Dent.* 2007;35(1):28-35. doi:10.1016/j.jdent.2006.04.003
- Maluf CV, Lourenço EJV, Pegoraro LF, de Moraes Telles D. Noncarious cervical lesions: response from a 25-year clinical follow-up study. *J Prosthet Dent.* 2025;133(3):653-661. doi:10.1016/j.prosdent.2023.11.001
- Folwaczny M, Mehl A, Kunzelmann KH, Hickel R. Clinical performance of a resin-modified glass-ionomer and a compomer in restoring non-carious cervical lesions: 5-year results. *Am J Dent.* 2001;14(3):153-156.
- Blunck U. Improving cervical restorations: a review of materials and techniques. *J Adhes Dent.* 2001;3(1):33-44.
- Burgess JO, Gallo JR, Ripps AH, Walker RS, Ireland EJ. Clinical evaluation of four Class 5 restorative materials: 3-year recall. *Am J Dent.* 2004;17(3):147-150.
- Gonçalves DFM, Shinohara MS, Carvalho PRMA, et al. Three-year evaluation of different adhesion strategies in non-carious cervical lesion restorations: a randomized clinical trial. *J Appl Oral Sci.* 2021;29:e20210192. doi:10.1590/1678-7757-2021-0192
- Canali GD, Ignácio SA, Rached RN, Souza EM. One-year clinical evaluation of bulk-fill flowable vs regular nanofilled composite in non-carious cervical lesions. *Clin Oral Investig.* 2019;23(2):889-897. doi:10.1007/s00784-018-2509-8
- Zhang H, Wang L, Hua L, et al. Randomized controlled clinical trial of a highly filled flowable composite in non-carious cervical lesions: 3-year results. *Clin Oral Investig.* 2021;25(10):5955-5965. doi:10.1007/s00784-021-03901-z
- Aw TC, Lepe X, Johnson GH, Mancl L. One-year clinical evaluation of an ethanol-based and a solvent-free dentin adhesive. *Am J Dent.* 2004;17(6):451-456.
- Van Dijken JWV, Sunnegårdh-Grönberg K, Lindberg A. Clinical long-term retention of etch-and-rinse and self-etch adhesive systems in non-carious cervical lesions: a 13-year evaluation. *Dent Mater.* 2007;23(9):1101-1107. doi:10.1016/j.dental.2006.10.005
- Burrow MF, Tyas MJ. Five-year clinical evaluation of One-Up Bond F in non-carious cervical lesions. *Am J Dent.* 2007;20(6):361-364.
- Tay FR, Pashley DH. Resin bonding to cervical sclerotic dentin: a review. *J Dent.* 2004;32(3):173-196. doi:10.1016/j.jdent.2003.10.009
- Cairo F, Nieri M, Pagliaro U. Efficacy of periodontal plastic surgery procedures in the treatment of localized facial gingival recessions: a systematic review. *J Clin Periodontol.* 2014;41(suppl 15):S44-S62. doi:10.1111/jcpe.12182