Objectives: To review the available scientific literature on the restorative treatment of non-carious cervical lesions; in particular, the restorative materials that present optimal performance in this type of clinical situation.

Methods: A literature review was performed using Pubmed search engine with the aim of determining the ideal restorative material for restorations of non-carious cervical lesions.

Results: Beautifil II (Shofu INC.) restorative material showed satisfactory results in terms of fracture resistance, flexural strength and excellent aesthetics, in addition to components that act as anti-cariogenic, anti-plaque and oral pH balance. The Clearfil SE Bond adhesive (Kuraray NORITAKE) showed in clinical research the highest bond strength rate compared to other adhesive systems available in the dental market.

Conclusion: Non-carious cervical lesions are multifactorial lesions that require the professional knowledge to conduct the treatment effectively. The Shofu Beautifil II showed the best results in fracture resistance, flexural strength and excellent aesthetics, it has anticariogenic potential, anti-plaque bacteria and contributes to the oral pH balance. The Clearfil SE Bond adhesive showed the highest retention rate among its competitors.

Keywords: Restorative materials, non-carious cervical lesions, class V.

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INTRODUCTION

Non-carious cervical lesions (NCCL) are commonly found in dental practice. They present as characteristic wear in the cervical area of the tooth, region in which the enamel presents less thickness and therefore becomes susceptible to chemical, physical and mechanical agents. If there is no clinical intervention, this loss of hard tissue may progress to dentin exposure and loss of the cementoenamel junction.1,2

Its etiology is not related to caries disease; the cause is multifactorial and may affect all age groups, with higher incidence in older people.3 All teeth can be affected by this lesion, but its prevalence is in upper bicuspid teeth.4 This pathological wear can compromise pulp vitality, function, aesthetics, as well as cause uncontrolled sensitivity, facilitate the development of caries and hinder the use of removable partial dentures.5

The NCCLs result from abrasion, erosion and abfraction, and present themselves as small depressions or in the form of grooves but may reach more severe depths in the form of wedges.6 Abrasive damage
is caused by friction, such as traumatic
brushing and/or toothbrushes, erosion
damage is caused by acids of non-
pathogenic origin, either intrinsic or
extrinsic. Abrasion is related to
increased occlusal load, developing
excessive tension between enamel and
dentin from molar occlusion, missing
teeth, para-functional habits such as
bruxism, and concentration of forces in
orthodontic treatments. 

The variation in the
caracteristics and incidences of
NCCLs among people is common. This
is due to the diversity of causes and
the simultaneous association of etiological
factors to dental wear. The control
and/or elimination should be the first
step of the therapeutic protocol. In
specific cases, restoration of the site
affected by the lesion is necessary. 
Dursun et al. reported in their
research that gingival recession and
root exposure may be associated with
NCCLs and in these cases periodontal
treatment is necessary.

Restorative treatment is
challenging when taking into account
lesion anatomy, adhesion to sclerotic
dentin, load concentration that the
cervical region is subjected to, and
marginal adaptation. The operative
field should be isolated to contain
moisture and not have soft tissue
interference.

Typically, the materials used
to NCCLs restorations are resin
composites (RC) and glass ionomer
cements (GIC). Importantly,
restoration longevity is multifactorial
and depends on the effectiveness of
bonding agents, acid etching, and
curing methods. Possible failures in
these steps can lead to the
development of new diseases, such as
caries.

Conventional glass ionomer
cements (GICs), in the category of
bioactive restorative materials, have
the highest concentration of fluoride
release/recharge to the oral
environment. Their modulus of
elasticity is low, they have ionic
adhesion to substrates and
biocompatibility. Among their
limitations are poor esthetics, high
solubility, low attachment rate, low
wear resistance, and low flexural
strength.

Resin-modified glass ionomer
cements (RGIcs) have resin monomers
and photosensitive components in
their composition. Besides the
advantageous properties of GICs, there
were improvements in wear resistance
and postoperative sensitivity rate
compared to conventional GIC. However,
they present mechanical failures when used in areas of load
concentration.

Regular resin composites are
preferred choices by clinicians. They
have satisfactory esthetic results,
marginal integrity, good wear
resistance, a variety of color shades,
and low long-term failure rates. Their
disadvantage is polymerization
shrinkage.

Fluid or flow resins composite
(FRC) have low viscosity, low modulus
of elasticity compared to regular resin
composites, good wear resistance and
good esthetics. Their limitations are
their mechanical properties.

Giomers bioactive resin
composites, besides presenting the
physical and mechanical properties of
regular RC, have the potential to
release/recharge fluoride to the oral
environment as the GICs, able to induce
remineralization and inhibit the
formation of caries and have
"chameleon" effect incorporating the
color tone of the dental element.

The aim of this study was to
review the available scientific
literature on the restorative treatment
of non-curious cervical lesions; in
particular, the restorative materials
that present optimal performance in
this type of clinical situation.

LITERATURE REVIEW

For many years researchers
have studied the etiology, treatments
and prevalence in different
populations for NCCL. Knowledge of
the clinical features and causative
agents, together with the patient's
anamnesis, is of great relevance to
reach the correct diagnosis of an
existing lesion. Intervention in the
initial phase avoids the destruction of
healthy structures and eliminates the
chance of new diseases.

In most cases, patients seek
dental help when they present
hypersensitivity or aesthetic defects.
In some cases the sensitivity is
moderate because of the accumulation
of biofilm, calculus, or gums over the
lesion. The removal of this coverage
exposes the lesion and leaves it
sensitive and vulnerable to the action
of biological, mechanical and chemical
factors that are associated with the
systemic behavior of each
individual.

The presence of pain helps the
identification of the problem, in the
location of the lesion, and in the
therapeutic decision. During the
anamnesis and intra-oral examination,
it is possible to identify behavioral and
eating habits that may hypothesize the
development of the lesion. The causes
may be erosive wear, abrasive wear
and/or abfraction.

Erosion is defined as a loss of
dental hard tissue caused by an acid
substance with no bacterial
involvement, with extrinsic origins
related to the consumption of acidic
and citric beverages and foods, or
intrinsic from gastric acids generated
by eating disorders.

Abrasion results from
frequent contact and excessive forces
on teeth with objects or substances,
without interference from occlusal
force, such as: traumatic brushing,
brush bristle hardness, brushing
time and frequency, and abrasive
dental products. Clinically, they can be
observed as grooves in the tooth
structure.

Abfraction is wear caused by
traumatic occlusal force; this stress is
more concentrated in the cervical third
of the tooth, causing enamel microfractures and prism rupture. The causes of this destruction are parafunctional habits, temporomandibular joint disorders, poor distribution of occlusal force and enamel fragility over the years, justifying the incidence in older people.10,27

Available restorative materials for restorations of non-carious cervical lesions:

Glass ionomer cement (GIC)

Formed by glassy powder and poly-carboxylic acid liquid, conventional GICs are fluoridated restorative materials, popularly used in pediatric dentistry and preventive treatments such as sealing of pits and fissures. Their potential to release/recharge fluoride to the oral environment favors tooth remineralization and hinders the development of caries. The concentration released by fluoride is greatest in the first 48 hours, after which the release is lower, continuous, and prolonged.28

They present ionic adhesiveness to calcified substrates and biocompatibility. In restorations that require mechanical and aesthetic properties, GICs do not present satisfactory results due to poor color stability, handling difficulties related to their viscosity, solubility, and retention failures.19,29

Resin-modified glass ionomer cement

(RGIC)

Developed in 1970 by Wilson and Kent, the conventional glass ionomer cement underwent modifications to improve its physical and mechanical properties. Thus, resin modified glass ionomer cements (RGIC) were developed, containing resin monomers and photosensitive components. They show better solubility, wear resistance and reduced setting time compared to conventional GIC. However, their color stability is poor and they do not have good wear resistance.20,28

Regular resin composite

Regular resin composites (RC) are often used in restorative treatments of NCCLs, as they have excellent esthetic results and good resistance to wear. However, components present in the resins exhibit polymerization shrinkage, and this generates stress at the adhesive tooth-restoration interface. To minimize the effects of this contraction, insertion of the resin composite into the cavity should be incremental.17

The high modulus of elasticity present in RC decreases the flexibility of the restoration during occlusal loading, to which teeth are subjected during function. The failure of NCCL restorations of this hybrid material may be associated with its hardness.31

Flow resin composite

Flow resins composite are syringe-shaped, designed to be injected directly into the area of interest, facilitating the insertion procedure. Their low viscosity allows the material to flow throughout the cavity, ensuring good marginal adaptation.32

Their properties allow minimally invasive restorations, sealing of pits and fissures, lining of cavities, and have a low rate of adhesive failure in regions of stress concentration, such as in restorations of non-carious cervical lesions. However, they have poor mechanical properties.33

Fluid composites differ from regular composites in that they have low viscosity. Some materials achieve this fluidity by reducing the content of filler particles in their composition, while others rely on the increase of diluent monomers in their matrix, which explains the variations in flow of materials sold in the dental market.34,35

The modulus of elasticity of flowable resin composites can be up to 30% lower when compared to regular RC, ensuring that this restorative material has good flexibility, thus mitigating the effects of polymerization shrinkage stress at the tooth-restoration interface and the effects of occlusal forces.32,26

Bioactive resin composite (GIOMER)

These are restorative materials that present the combination of the properties of RC and GIC, developed by the company Shofu INC. (Kyoto, Japan) in the early 2000’s. Giormer is classified as an intelligent material, capable of releasing and recharging fluoride present in the oral environment. This phenomenon occurs by chemical reactions, and its composition counts on S-PRG (Surface Pre-Reacted Glass Ionomer) particles that absorb the fluoride present in toothpastes and mouthwashes and release it to the oral environment when the fluoride ion levels are low. In case of interaction with oral fluids during the handling of the restorative material, the surface of the S-PRG particle protects the glass core from the negative effects that moisture can have on the restorative material.37

The S-PRG technology, in addition to releasing fluoride ions, provides sodium, silicate, aluminum, borate and strontium ions to the environment. These ions have the biological functions of inhibiting plaque formation, preventing Streptococcus mutans from adhering to the enamel surface and helping to maintain a balanced oral pH. Strontium and fluoride bind to hydroxyapatite crystals, favoring the formation of apatite and fluoroapatite.38

Restorative materials containing Giormer technology are easy-to-handle materials; their optical properties resemble natural teeth, having the "chameleon" effect of
incorporating the color of the surrounding substrate, but if necessary, specific shades can be added to mimic the dental element.\(^{39}\)

**DISCUSSION**

It is estimated that about 25% of the population has non-carious cervical lesions.\(^{29}\) The cervical area of the tooth is the most vulnerable to wear because the enamel is less thick and has less protein and mineral content, and the dentin is less resistant.\(^{4,21}\)

Factors such as abrasion, erosion and abrasion cause these cervical lesions, and their evolution is slow and irreversible. It causes the disappearance of the cemento-enamel junction, and may cause dentin exposure to the oral environment, hypersensitivity, and in more advanced lesions, pulp necrosis. Dentin exposure alters the dentin surface, making it sclerotic; this fact occurs by obliteration of the dentinal tubules, which promote sealing to protect the pulp canal.\(^{16,41}\)

The NCCL affect people of all ages, with prevalence in older people because their teeth have been exposed for longer to chemical and physical factors, behavioral habits and diet.\(^3\) Their incidence is in upper bicuspids teeth and the buccal surface. The lesions in the initial phase may present as white spots, shallow disc-shaped surface, but may evolve to deep cavities, usually wedge-shaped.\(^6,27\)

Erosion wear is caused by gastric acids, caused by eating disorders such as bulimia, anorexia, regurgitation and refluxes, and by acids present in foods and beverages such as soft drinks, juices, citrus fruits and dried fruits, tomato sauce, wines, isotonic drinks, teas, vinegars and vitamin C drinks.\(^{5,24}\) Bartlett et al.\(^6\) in clinical studies with over 3,000 adults in 7 European countries, correlated the developments of NCCLs to beverages with a high concentration of carbohydrates present that stimulate acid production.

Abfraction is generated by frequent contact or applied force of the teeth to objects or substances.\(^{5,9}\) In 66% of the cases it is due to the frequency and excessive force in tooth brushing, hardness of the toothbrush filaments and abrasive toothpastes present in toothpastes and hard foods.\(^{10}\) The energy generated is concentrated in the cervical region of the teeth, causing groove-like lesions.\(^{19}\)

Abfraction comes from traumatic occlusal compressive, shear and traction forces. It causes microfractures in the cervical third of the enamel, dentin elasticity and reduction of the HUNTER-SCHREGER band thickness. With the vulnerability of the cervical region, acidic and abrasive agents become adjuvants for lesion progression.\(^2\) Grippo et al.\(^9\) described that wear may be caused by masticatory cycles, deleterious habits such as bruxism, poor distribution of occlusal forces, tooth anatomy and presence and size of restorations. This lesion has a wedge shape and defined limits.

It is difficult to point a single etiological factor that causes the NCCL, because it is multifactorial and has co-factors that can aid in degradation, such as saliva pH and integrity of hard and soft tissues around the tooth.\(^{10,23}\) Researchers believe that the association of etiologic factors are the cause of the development of the lesion.\(^6,7\)

NCCLs may present different signs and symptoms among people; however, treatments follow the particularity of each individual.\(^{20}\) In some cases, restorative treatment is indicated, and when there is root exposure periodontal treatment is essential.\(^{42}\)

The target of many studies by researchers around the world, glass ionomer cements and resin composites have undergone improvements in their properties. Although conventional GICs and RGICs have been applied in NCCL restorations, their limitations are mechanical strength, color stability, and retention.\(^{28}\)

In a three-year randomized clinical study, Celik, et al.\(^{31}\) compared lesions restored with CIVRM and RC. The results showed that restorations with CIVRM had inferior clinical performance to those performed with RC, the main problems were loss of retention and reduced surface gloss.

Resin composites are the restorative materials of preference by clinicians, especially in restorations of anterior teeth and class V lesions,\(^3\) because they show excellent results in mechanical and optical resistance (fluorescence and opacity), various shades of colors and chemical compatibility to natural teeth.\(^4\) Ferracane\(^35\) describes clinical studies from 10 to 20 years with satisfactory results in resin composites restorations, with failure rates of 2% per year.

Shaalan et al.\(^{43}\) reports that restorations in NCCL performed with flowable and conventional composites had good results, showing no significant differences, but in posterior teeth the flowable RC showed mechanical failure.

In the early 2000s, Giomers are inserted in the dental market by the company Shofu INC. (Kyoto,Japan). This RC classified as an intelligent material, has in its composition the association CIV, presenting mechanical properties, biocompatibility, fluoride release/recharge and color shades. Moreover, it has particles with S-PRG technology, which provides the oral environment with ions of sodium, silicate, aluminum, borate and strontium, with biological functions to inhibit plaque formation and help balance oral pH.\(^{37,39}\)

Rusnac et al.\(^{44}\) describe in their studies that Giomers have the advantages of mechanical strength and aesthetic finishes of RCs and
anticariogenic properties of GICs. Gordan et al.\(^{38}\) report longevity studies with Giomer demonstrating excellent strength, aesthetic and retention results. According to Pecie et al.\(^{45}\) Giomers show significantly better surface finish and aesthetic quality when compared to conventional GICs and GICMRs.

Garoushi et al.\(^{46}\) subjected the fluoride restorative materials, Dyract, CompGlass, BEAUTIFIL II, ACTIVARestora and GC Fuji II LC to wear testing with 15,000 mastication cycles using a dual-axis simulator. The Beautiful II material (Shofu INC.) exhibited high fracture toughness values and showed the best flexural strength result of 145 MPa under dry and wet conditions. According to the author, the mechanical and physical property of Giomer, is due to the S-PRG technology.

Similarly, Burtea et al.\(^{47}\) performed laboratory tests to evaluate flexural strength of Giomer Beautiful II (Shofu INC.) and the recorded value was 115.7 MPa, surpassing values of the ISO 4049/2000 standard that establishes 80 MPa.

Gordan et al.\(^{38}\) conducted clinical studies evaluating the behavior of restorations made with Giomer resin composites combined with a self-conditioning primer. The patients ranged in age from 21 to 62 years old. After 13 years of follow-up, they concluded that Giomers are excellent restorative materials in NCCL treatments, mainly because it is an area of difficult retention, marginal adaptation and stress concentration\(^{44}\).

One of the main failures of restorations is microleakage at the restoration-tooth interface, causing postoperative sensitivity, detachment, and development of secondary caries. Treatment success depends on the effectiveness of the adhesive system used to bond the resin-substrate interface\(^{14}\). The 37% phosphoric acid is an adhesive for this adhesion, according to Kwasnirikul et al.\(^{47}\) in sclerotic dentin, acid etching should follow the standard protocol, increasing the time of the acid action to sclerotic dentin does not change the effectiveness of this procedure.

Van Meerbeek et al.\(^{48}\) performed clinical performance evaluations of 13 bonding agents on NCCLs with a 13-year follow-up. Only five adhesives showed a retention rate greater than 50%. The 3-step adhesive Clearfil Liner Bond (Kuraray) with 74% retentivity; the glass ionomer modified resin Vitremer (3M ESPE) with 64%; 3-step Syntac Classic (Ivoclar-Vivadent) with 64%; 3-step Optibond Dual Cure (Kerr) with 59% and the 2-step adhesive ART Bond (Cöltöne, Altstätten, Switzerland) with 59%.

In a follow-up also of 13 years, Peumans et al.\(^{49}\) subjected two adhesive systems considered the gold standard to retention tests. The adhesive Clearfil SE Bond (Kuraray) showed a 96% rate and the Optibond FL (Kerr,Orange, CA, USA) the rescored rate was 94%.

It is believed that as important as the choice of restorative material and bonding system, are the care and methods in the light-curing process\(^{39,45}\).

Research conducted by Leprince et al.\(^{50}\) reported that factors may interfere in the light-curing stage such as physical-mechanical properties of the restorative material, its viscosity, the thickness inserted in the preparation, color shades (darker shades require a longer time to set), the depth of the cavity, light intensity, time, temperature, positioning and distance between the tip of the light-curing device and the resin composite.

According to Ferracane\(^{17}\) the main failures caused by the stress of polymerization contraction are marginal infiltrations and displacement of the restoration, and this stress can be transferred to the tooth structure and cause cracks and enamel fractures. Van Dijken\(^{51}\) complements this and describes that these failures can cause marginal staining, development of secondary caries, and postoperative hypersensitivity.

The risks of polymerization shrinkage can be reduced with incremental RC techniques to the cavity preparation. This increment alternated with the polymerization light reduces the speed of volumetric shrinkage\(^{17}\).

In addition to the direct technique of incremental restorative materials in NCCL, the semi-direct technique can be performed. Published in 2019, Caneppele et al.\(^{52}\) performed a two-year randomized clinical evaluation of resin composite with direct and semi-direct technique in NCCL restorations. The results showed greater failures in the semi-direct technique, for the authors this technique was not shown to be advantageous, for presenting greater clinical preparation time compared to the direct technique and for the difficulty of working with a small fragment of extra oral restoration, requiring the professional skill and knowledge.

In summary, the NCCL should receive specific attention and care, restorative materials return the lost structure, aesthetics and occlusal function of the affected elements\(^{53}\). As we know, each step performed correctly results in the success and longevity of treatment, such as isolation of the operative field, choice of adhesive systems, acid etching, techniques for incrementing RC into the cavity, and light-curing method\(^{14}\).

Some researchers advocate the idea of performing a grinding treatment on the sclerotic surface in order to improve the retention rate of the restoration\(^{40}\). Based on this concept, Correa et al.\(^{54}\) after results of a systemic meta-analysis review, describe that the characteristics of NCCLs do not interfere with the success of the restoration. Soares and
Grippo performed 3D finite element analysis of stress concentration in NCCLs of different morphologies with RC restorations. In summary, the authors describe that these internal roundings cause an increase in lesion size and cause pulpal irritation. However, this intentional wear disrupts the philosophy of minimally invasive dentistry.

**CONCLUSION**

With the limitations of this study, we can conclude that:

1. NCCLs are multifactorial lesions that require the professional knowledge to conduct the treatment effectively.
2. The Giomer, Beautifil II (Shofu INC.) showed the best results in fracture resistance, flexural strength and excellent aesthetics, it has antiangiogenic potential, anti-plaque bacteria and contributes to the oral pH balance.
3. The bonding agents are essential for the retention of the restoration and its longevity, the Clearfil SE Bond adhesive system (Kuraray) showed the highest retention rate among its competitors.
4. It is essential that the clinician knows the light-curing methods, the risks inherent to failure and insertion techniques to reduce polymerization shrinkage.

**CONFLICT OF INTEREST**

The authors certify that this research is free of conflicts of interest.

**REFERENCES**


