Abfraction lesions reviewed: current concepts

Uma revisão sobre lesões de abfração: conceitos atuais

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ABSTRACT

Non-carious cervical lesions are characterized by structural loss near the cementoenamel junction, without the presence of caries. A number of theories have arisen to explain the etiology of such lesions, although the real causes remain obscure, as is reflected by the contradictory terminology used in the literature. In addition to describing acidic and abrasive processes documented as etiological factors, attention is given to the role of mechanical stress from occlusal load, which is the most accepted theory for the development of abfraction lesions. Considering that tensile stress leads to the failure of restorations in the cervical region and that this is a fruitful area for future research, the present study has highlighted diagnosis, prognosis and the criteria for treatment.
Indexing terms: *finite element analysis; tooth abrasion; tooth cervix.*

RESUMO

As lesões cervicais não cariosas são caracterizadas pela perda de estrutura próxima à junção cemento-esmalte sem a presença de cárie. Algumas teorias têm surgido para tentar explicar a etiologia dessas lesões, embora as causas verdadeiras permaneçam obscura devido à terminologia contraditória na literatura. Apesar dos processos abrasivos e erosivos serem apontados como fatores etiológicos, atenção é dada ao papel da força biomecânica das cargas oclusais que é a teoria mais aceita para o desenvolvimento das lesões de abfração. Ao considerar que falhas de restauração podem ocorrer por tensões de tração e que constituem área promissora para pesquisas futuras, o presente trabalho demonstra os conceitos atuais sobre diagnóstico, prognóstico e critérios para o tratamento.
Termos de indexação: análise de elemento finito; abrasão dentária; colo do dente.

INTRODUCTION

Non-carious cervical lesions are often observed on the buccal surfaces of teeth, but seldom on lingual and rarely on proximal surfaces. They are more frequent on incisors, canines and premolars and more prevalent in the maxilla than in the mandible[1]. These lesions vary from shallow grooves to broad dished-out lesions or large wedge-shaped defects with sharp internal and external line angles[2]. They have been attributed to three factors (abrasion, attrition and erosion) acting independently or together[3]. Moreover, it has been related that tensile stresses resulting from occlusal overload may be involved in the development of non-carious cervical lesions[4,5].

It has been suggested that lateral forces can create tensile stress that disrupts hydroxyapatite crystals in the enamel, allowing small molecules, such as those of water to penetrate and render these crystals more susceptible to chemical attack and further mechanical deterioration[5]. In this case, it has been termed abfraction[6]. This is a condition observed on the buccal surface at the cementoenamel junction of teeth, with prevalence ranging from 27 to 85%[7]. It is described as the clinical entity characterized by loss of hard tissues caused mainly by a non-functional distribution of occlusal loads[6].

When a tooth is hyperoccluded, the masticatory forces are transmitted preferentially to this tooth, which in turn transfers this energy to the cervical region[8,9]. Lateral force produces compressive stress on the side towards which the tooth bends and tensile stress on the other side[5]. The stresses create microfractures in the enamel or dentine adjacent to the gingival region. These fractures propagate in a direction perpendicular to the long axis of the tooth leading to a localized defect around the cementoenamel junction[9,10].

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Occlusal forces increase microleakage and gap formation at the cement/dentinal margin[11]. Continual occlusal loading produces displacements and stresses under the buccal cervical enamel and dentin, increasing crack initiation and encouraging loss of restoration[12]. This occurrence can require restorative treatment in most patients and it sometimes leads to hypersensitivity or further degradation of hard tooth tissues[10]. Thus, the selection of restorative materials represents a critical factor for successful restoration[13] due to the position of these lesions, which makes it difficult to provide a long-lasting restoration[14].

While the role of occlusal forces in the etiology of abfraction lesions has been widely discussed[4-6,15,16], many materials and techniques have been tried in an attempt to obtain the best clinical performance[14]. The following materials are indicated for restoring cervical lesions: glass-ionomer cements, resin-modified glass-ionomer cements, polyacid-modified resin-based composites (compomers) and composites resins[17-19]. However, clinical studies have shown repeatedly that restorations of abfraction lesions have inadequate retention rates, with a higher percentage of failure in the cervical area[20].

Considering that mechanical stress is accepted as a cause of restoration failures, the present study has emphasized the contemporary concepts in diagnosis, prognosis and treatment measures of abfraction lesions.

Development of abfraction lesions

Bruxism may be the primary cause of angled notches at the cementoenamel junction. It was postulated that tooth flexure from tensile stress led to cervical wear[4]. It has been hypothesized that the primary etiological factor in wedge-shaped cervical erosions was the impact of tensile stress from mastication and malocclusion. The wear is created by a combination of bending and barreling deformations that cause alternating tensile and compressive stresses, which lead to weakening of the enamel and dentin[5]. A new category - abfraction – was introduced into the classification of non-carious cervical lesions to refer to the type of pathologic loss of hard tissue at the cementoenamel junction caused by biomechanical loading forces that result in enamel and dentin flexure at a location away from the loading. The term is used to distinguish it from erosion and abrasion[6].

The tooth flexure theory postulates that the biomechanical effects of occlusal loading are the main factors that initiate the formation of non-carious cervical lesions[6]. Many of these cervical defects that were thought to be extrinsic factors acting directly upon the surface of the tooth are actually due to eccentrically applied occlusal forces, such as those produced during bruxing[3,5,6,21]. This can be explained because in normal mastication, occlusal forces are loaded along the long axis of the tooth. Thus, force dissipates, and the distortion of enamel and the dentinal crystal is minimal[10]. Nevertheless, when occlusal loading is not ideal, lateral forces may be generated causing the tooth to flex[22].

The side towards which the tooth is bending experiences compression, while the side opposite to the direction of force is placed under tension[5]. Since the tooth substance is capable of resisting great compression, no disruption of enamel or dentine would usually occur on this side, but tensile forces may cause disruption of the bonds between hydroxyapatite crystals, leading to cracks in the enamel and eventual loss of enamel and the underlying dentine[5,6].

Grippo[6] has suggested that abfraction is the basic cause of all non-carious cervical lesions. There is some evidence supporting the tooth flexure theory: presence of class V non-carious lesions in some teeth but adjacent teeth (not subjected to lateral forces) are unaffected[22,23]; the lesions progress around restorations that remain intact[3] and under the margins of complete crowns[23]; the lesions are rarely seen on the lingual aspect of mandibular teeth[22]; the major incidence is in patients who are bruxists[24] and lesions may be subgingival[3]. However, other studies have proposed a combination of occlusal stress, parafunction, abrasion, and erosion in the development of lesions, leading to a conclusion that the progression of abfraction may be multifactorial[5,16].

The cervical fulcrum area of a tooth might be subject to unique stress, torque, and moments resulting from occlusal function, bruxing, and parafunctional activity[15]. Nevertheless, it is important to know how periodontal status is involved to the development of cervical lesions. Alveolar bone loss changes the position of the fulcrum of bending moment causing more apically placed lesions[21]. Indeed, loss of periodontal support leading to a high degree of tooth mobility may conversely be a protective factor, rather than flexing at the cementoenamel junction[25]. Generally, mobile teeth are not as frequently affected as non-mobile teeth. It may be that the mobility of the tooth dissipates the stress[23].

Researches and clinicians are paying increased attention to noncarious cervical lesions. This interest has resulted in a substantial number of contributions to the dental literature as regards abfraction lesions, with the aim of determining the etiological factors, characteristics, therapeutic measures and prognosis (Table 1).

Table 1. Studies comparing abfraction with cervical wear.

Author	Reference	Type of Study	Outcome
Xhonga[24]	J Oral Rehabil (1977)	Clinical	occlusion related to cervical wear (bruxism)
Lee and Eakle[5]	J Prosthet Dent (1984)	Hypothesis	occlusal forces related to cervical wear
Heymann et al.[26]	J Am Dent Ass (1991)	Clinical	tooth flexural theory of restorative retention
Braem et al.[3]	J Prosthet Dent (1992)	Case Report	occlusal forces related to cervical wear
Levitch et al.[7]	J Dent (1994)	Lit Review	occlusal forces related to cervical wear
Spranger[16]	Quintessence Int (1995)	Lit Review	parafunction as a cofactor in the abfraction development
Burke et al.[22]	Dent Update (1995)	Lit Review	multifactorial etiology/ occlusal forces as main factor
Lee and Eakle[15]	J Prosthet Dent (1996)	Lit Review	flexure theory of restorative retention
Lyttle et al.[27]	J Prosthet Dent (1998)	Clinical	treatment with restorative materials
Rees and Jacobsen[28]	J Dent (1998)	Lab Study	occlusal forces related to cervical wear
Grippo et al.[29]	J Am Dent Ass (2004)	Lit Review	criteria for diagnosis and treatment methods
Pegoraro et al.[30]	J Am Dent Ass (2005)	Clinical	cervical lesions related to wear facets
Bernhardt et al.[31]	J Oral Rehabil (2006)	Clinical	multifactorial etiology
Peaumans et al.[19]	Dent Mater (2007)	Clinical	treatment with flexible restorative materials

Treatment decision: restorative technique and materials

The treatment will be ineffective in the long term should any predisposing factors not be brought under control[3,22]. Thus, to improve this situation and develop a better understanding of the cervical lesion, which is obviously relevant to the clinical treatment, it is highly desirable to analyze the stress distribution in teeth[10].

Since abfraction lesions implicate enamel and dentine margins, class V non-carious cervical lesions represent a challenge to the dental profession due to their position, which make it difficult to provide a long-lasting restoration[14]. It is well known that enamel and dentine respond differently to masticatory stresses. Although these tissues are intended to support each other, they can react to occlusal forces independently. Dentine has shown low compressive and high tensile stresses at the cementoenamel junction while enamel has demonstrated a reverse trend[32].

The continual occlusal loading produces displacements and stresses under the buccal cervical enamel and dentine, increasing crack initiation and favoring loss of the restoration[12,28]. In this case the stress concentration caused by the cervical lesion would facilitate further tooth structure deterioration[23]. It is well known that if the dentin and adhesive interface is exposed to the oral cavity, marginal discolorations, poor marginal adaptation and subsequent loss of retention of the restoration are frequent clinical findings[33].

Considering that mechanical stress is accepted as a cause of restoration failures in the cervical region, the restoration materials used include those that adhere to tooth substance, such as glass-ionomers, or resin composites retained by the use of dentin bonding agents[22]. With regard to current adhesive systems, they interact with the enamel/dentin substrate using two different strategies, either removing the smear layer (etch-and-rinse technique) or maintaining it as the substrate for bonding (self-etch technique). The classification relies on the number of the steps constituting the system[34]. Restoration is generally indicated to prevent propagation of the lesion and support the use of composite materials that bond and have an elastic modulus that allows elastoplastic deformation[23]. However, problems with obtaining and maintaining a good seal between the restoration and tooth at the margin have been found to be a primary reason for failure of Class V resin-based composite restorations[3,34].

The retention rate for restorations with a lower elastic modulus may be significantly better than a material with a higher elastic modulus[26]. Moreover, it seems that these flexible intermediate layers provide stress relief while the composite material is undergoing polymerization shrinkage, when compared with a restorative material which resists forces and may dislodge the restoration by flexing with the tooth[13,18].

Microfilled composites, which demonstrate greater elasticity than hybrid composites, may be appropriate if esthetics is a concern. With this type of resin, much of the transferred energy is absorbed by the restoration rather than transmitted to the dentin-restoration interface[9,19,26]. However, no significant difference was found in the parameters of retention, recurrent caries, staining or color match in a study comparing glass ionomers and composites, but there was greater surface roughness in glass ionomer restorations[22].

Glass ionomer materials have been found to perform significantly better than composites[35-37], possibly due to their greater resilience allowing the material to flex with the tooth, which is not possible with the more rigid composite materials. Resin-based glass ionomer cements may be of value, because they generally produce a more acceptable esthetic result than conventional glass ionomer material[22].

It is also important to report that restoring affected teeth improves the maintenance of patients' oral hygiene; decreases thermal sensitivity; prevents pulpal involvement and improves esthetics and strengthens the teeth. Since abfraction lesions are caused by biomechanical forces, occlusal adjustments and elimination of parafunctional habits are required to decrease the prevalence and slow the progress of established lesions[23,27].

Finite element analysis

In an attempt to reproduce the phenomenon of stress distribution in teeth and their anatomic support structures, a variety of methodologies have been used. With photoelasticity methodology is possible to determine sites of stress concentration but it does not quantify nor define the stress type (compression or tensile), and it is also difficult to build objects with more than one physical property[38]. A variety of other methods has been used to analyze the distribution of stress generated in the tooth and its adjacent structures, yet, new technologies inevitably encounter some difficulties, which make them vulnerable to criticism[39].

The Finite Element method is the most appropriate and important tool for evaluating the stress distribution in the cervical region. Because it is capable of analyzing stresses quantitatively and conducting parametric studies, each factor, such as physical and mechanical conditions, which is represented mathematically, can be rapidly modified and the stress distribution can be investigated in two-dimensional (2D) or three-dimensional (3D) models[41].

The occurrence of non-carious cervical lesions is very common on anterior and premolar teeth because they are of a smaller size[42]. Such lesions are more frequently found on the buccal or lingual surfaces due to the direction of occlusal or incisal loads, the angling and asymmetry of the tooth buccal-lingual plane, and its relationship with the supporting alveolar bone[40-41].

In premolar teeth, one can expect to find tensile stresses in the cervical region on the buccal surface. Oblique traumatic loading on the palatal cusp of the maxillary second premolar produces dental flexion in the buccal direction, resulting in tensile stress on the enamel in the cervical region. A variety of studies[5,10,26,44] have demonstrated that this is the main cause of rupture of the union between enamel crystals.

DISCUSSION

The occurrence of non-carious cervical lesions is very common on anterior and premolar teeth because they are of a smaller size[43], particularly the first premolars[30,31] and second premolars[31]. Moreover, such lesions are more frequently found on the buccal or lingual surfaces due to the direction of occlusal or incisal loads, angling and asymmetry of the tooth buccal-lingual plane, and its relationship with the supporting alveolar bone[43].

Previous clinical investigations have provided a great deal of evidence supporting the role of occlusal force in the etiology of non-carious cervical lesions. They have pointed out a relationship between the loss of cervical fillings and the presence of traumatic occlusal contacts[26]. Bruxing, clenching and other parafunctional habits lead to the magnitude of cervical stress and would increase non-carious cervical lesions formation[45]. Such clinical observations are in agreement with the results and substantiate the role of occlusal force in the etiology of these lesions[5,16,22]. Furthermore, wear facets, a sign of stressful occlusion, are present on teeth with non-carious cervical lesions, providing support for occlusal forces and flexure as casual factors[45].

Abfraction is the basic cause of all non-carious cervical lesions[6]. However, other studies proposed a multifactorial etiology with a combination of occlusal stress, parafunction, abrasion, and erosion in the development and progression of lesions[5,16,27]. This can be explained, because when occlusal loading is not ideal, lateral forces may be generated causing the tooth to flex[22] producing compressive stress on the side towards which the tooth bends and tensile stress on the other side[5].

Since abfraction lesions implicate enamel and dentine margins, class V non-carious cervical lesions represent a challenge to the dental profession due to their position, which makes it difficult to provide a long-lasting restoration[14] and because it is well known that enamel and dentin respond differently to masticatory stresses[32].

Mechanical stress is accepted as a cause of restoration failures in the cervical region, and therefore, the materials used for restoring the lesions include those that adhere to tooth substance. Nevertheless, close attention must be paid to occlusal adjustments during clinical and restorative treatments of non-carious cervical lesions and occlusal splints should be used in order to avoid further progression of abfraction lesions[22]. As mentioned previously, the treatment will be ineffective in the long term, should any predisposing factors not be brought under control[3,22]. This approach would thus include prevention and treatment of the resultant lesion[28].

Based on this information, the most significant consideration in the restoration of an abfraction lesion is the correction of possible prematurities before restoring the tooth[9]. To do so, an accurate diagnosis is required and evidence-based treatment for loss of dental tissue should consider restoration and the choice of material[27]. Composite resin restorations offer a more permanent solution because of the acid-etch technique and the chemical attachment to the tooth structure through dentinal bonding systems[23], in particular microfill composite resins[9]. Glass ionomers are effective for treating non-carious cervical lesions because of their potential to release fluoride[9]. In general, composites resins and glass ionomer are indicated for non-carious cervical lesions and offer the most esthetic and long-lasting solution[46].

CONCLUSION

Within the limitations of this report, the following conclusion must be taken into consideration. Occlusal forces are predictors of the presence of abfraction lesions. There is a significant correlation between these lesions and the cause of failure of the class V restorations. However, further research is required to confirm the cause and determine whether preventive and therapeutic measures would decrease the prevalence and progression of abfraction lesions.

Collaborators

A.F.V.PEREIRA, I.A.V.P. POIATE and E. POIATE JUNIOR participated in the conception, writing and corrections of the article. W.G.MIRANDA JUNIOR participated in the conception and corrections of the article.

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