UNIVERSIDADE FEDERAL DE UBERLÂNDIA
FACULDADE DE ODONTOLOGIA

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THIAGO SILVA PERES

INFLUENCE OF SEVERITY AND RESTORATION OF NON-CARIOUS CERVICAL LESION ON BIOMECHANICAL BEHAVIOR AND PREDICTABILITY OF DENTAL STRUCTURE FAILURE

INFLUÊNCIA DA SEVERIDADE E RESTAURAÇÃO DA LESÃO CERVICAL NÃO CARIOSA NO COMPORTAMENTO BIOMECÂNICO E PREVISIBILIDADE DE FALHA DA ESTRUTURA DENTAL

Uberlândia-MG

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Trabalho de conclusão de curso apresentado a Faculdade de Odontologia da UFU, como requisito parcial para obtenção do título de Graduado em Odontologia.

Orientador: Prof. Dr. Luís Henrique Araújo Raposo

Coorientador: Prof. Dr. Alexandre Coelho Machado

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RESUMO

Objetivo: analisar o comportamento biomecânico e a previsibilidade de falha da estrutura dental com diferentes níveis de severidade de lesões cervicais não cariosas (LCNC), restauradas ou não com resina composta, na aplicação de três diferentes tipos de cargas, utilizando o método de elemento finito (MEF). Metodologia: com base em um modelo de incisivo central superior, foram gerados, em um software CAD, um modelo hígido e outros quatro modelos com LCNC de diferentes níveis de profundidades (0,5 mm, 1,0mm, 1,5mm e 2,0mm, foram gerados no software CAD); além de seus modelos restaurados com resina composta para essas diferentes profundidades. Todos os modelos virtuais receberam três tipos de carregamento (100 N): carregamento de 45º com a superfície do terço médio palatino (TMP), mesma angulação com a superfície do terço incisal palatino (TIP) e outro axial na borda incisal (I). Os dados foram obtidos em MPa usando os critérios de Tensão Máxima Principal, Tensão Mínima Principal e Fadiga Mecânica. Resultados: os resultados para o critério Tensão Máxima Principal e Tensão Mínima Principal mostraram uma maior concentração de tensão nos modelos com LCNC associado ao tipo de carregamento TIP, seguido pelo TMP e, consequentemente, gerando menor sobrevida da estrutura cervical. Os modelos com restauração demonstraram um padrão homogêneo de distribuição de tensão e semelhante ao do modelo hígido. Conclusão: a presença de LCNC promoveu alta concentração de tensão na estrutura cervical dentária, sendo agravada progressivamente com a profundidade da lesão. A restauração com resina composta se mostrou eficaz no controle dos fatores etiológicos das LCNCs.

Palavras-Chave: Desgaste dos Dentes; Restauração Dentária Permanente; Oclusão Dentária.

SUMÁRIO

Abstract

Objective: to analyze the biomechanical behavior and the predictability of dental structure failure with different levels of severity of non-carious cervical lesions (NCCL), restored or not with composite resin, in the application of three different types of loads, using the finite element analysis (FEA). Methodology: based on an upper central incisor model, a sound tooth model and four others with NCCL of different depth levels (0.5 mm, 1.0 mm, 1.5 mm and 2, were generated in CAD software); beside the restored models with composite resin of these different depth. All virtual models received three types of loading (100 N): loading of 45º with the surface of the palatal middle third (PMT), same angle with the surface of the palatal incisal third (PIT) and axial load in the incisal edge (IE). The data were obtained in MPa using the Maximum Principal Stress, Minimum Principal Stress and Mechanical Fatigue criteria. Results: The Maximum Principal Stress and Minimum demonstrated a higher concentration of stress in models with NCCL associated with the type of loading PIT, followed by PMT and, consequently, generating lower survival on cervical structure. The models with restoration brought a homogeneous pattern of stress distribution and similar to sound tooth model. Conclusion: the presence of NCCL promoted higher stress concentration in the cervical dental structure, being progressively higher as depth the lesion. The composite resin restoration proved to be effective in the control of NCCL's etiological factors.

Keywords: Tooth Wear; Permanent Dental Restoration; Dental Occlusion.

Resumo

Objetivo: analisar o comportamento biomecânico e a previsibilidade de falha da estrutura dental com diferentes níveis de severidade de lesões cervicais não cariosas (LCNC), restauradas ou não com resina composta, na aplicação de três diferentes tipos de cargas, utilizando o método de elemento finito (MEF). Metodologia: com base em um modelo de incisivo central superior, foram gerados, em um software CAD, um modelo hígido e outros quatro modelos com LCNC de diferentes níveis de profundidades (0,5 mm, 1,0mm, 1,5mm e 2,0mm, foram gerados no software CAD); além de seus modelos restaurados com resina composta para essas diferentes profundidades. Todos os modelos virtuais receberam três tipos de carregamento (100 N): carregamento de 45º com a superfície do terço médio palatino (TMP), mesma angulação com a superfície do terço incisal palatino (TIP) e outro axial na borda incisal (I). Os dados foram obtidos em MPa usando os critérios de Tensão Máxima Principal, Tensão Mínima Principal e Fadiga Mecânica. Resultados: os resultados para o critério Tensão Máxima Principal e Tensão Mínima Principal mostraram uma maior concentração de tensão nos modelos com LCNC associado ao tipo de carregamento TIP, seguido pelo TMP e, consequentemente, gerando menor sobrevida da estrutura cervical. Os modelos com restauração demonstraram um padrão homogêneo de distribuição de tensão e semelhante ao do modelo hígido. Conclusão: a presença de LCNC promoveu alta concentração de tensão na estrutura cervical dentária, sendo agravada progressivamente com a profundidade da lesão. A restauração com resina composta se mostrou eficaz no controle dos fatores etiológicos das LCNCs.

Palavras-Chave: Desgaste dos Dentes; Restauração Dentária Permanente; Oclusão Dentária.

Resumen

Objetivo: analizar el comportamiento biomecánico y la predictibilidad de la falla de la estructura dentaria con diferentes niveles de severidad de lesiones cervicales no cariosas (LCNC), restauradas o no con resina compuesta, en la aplicación de tres tipos de cargas diferentes, utilizando el elemento finito análisis (EFA). Metodología: basado en un modelo de incisivo central superior, un modelo sano y otros cuatro modelos con LCNC de diferentes niveles de profundidad (0.5 mm, 1.0 mm, 1.5 mm y 2, fueron generados en software CAD). 0 mm, se generaron en el software CAD); además de sus modelos restaurados con resina compuesta para estas distintas profundidades. Todos los modelos virtuales recibieron tres tipos de carga (100 N): carga de 45º con la superficie del tercio medio palatino (TMP), misma angulación con la superficie del tercio palatino incisal (TIP) y otra axial en el borde incisal (I). Los datos se obtuvieron en MPa utilizando los criterios de Esfuerzo Principal Máximo, Esfuerzo Principal Mínimo y Fatiga Mecánica. Resultados: los resultados para el criterio de Máxima Tensión Principal y Mínima Tensión Principal mostraron una mayor concentración de tensión en los modelos con LCNC asociada al tipo de carga TIP, seguida de TMP y, en consecuencia, generando menor supervivencia de la estructura cervical. Los modelos con restauración mostraron un patrón de distribución de estrés homogéneo y similar al del modelo sano. Conclusión: la presencia de LCNC promovió una alta concentración de tensión en la estructura cervical dentaria, empeorando progresivamente con la profundidad de la lesión. La restauración de resina compuesta demostró ser eficaz para controlar los factores etiológicos de las LCNC.

Palabras Clave: Desgaste de los Dientes; Restauración Dental Permanente; Oclusión Dental.

1. Introduction

The advances in dentistry associated with preventive public health activities, reduce the tooth loss related to caries and other oral diseases. In view of this scenario and the aging of the world population, individuals remain with their natural teeth for a longer time, collaborating to the increase of non-carious lesions (Que et al., 2013; Soares & Grippo, 2017). Among these pathological conditions, non-carious cervical lesions (NCCL) have a high global prevalence, reaching up to 46.7% between adults and increasing even more in the elderly (Teixeira et al., 2020). NCCL are characterized by their complex multifactorial etiology, involving three main factors: stress (wear caused by the distribution of occlusal forces), friction (by physical means, such as attrition, abrasion and erosion) and biocorrosion (by chemical, biochemical and electrochemical means) (Grippo et al., 2012; Soares & Grippo, 2017).

The comprehension of biomechanical behavior involved in the chewing process and oral parafunctional habits is highly relevant for understanding the mechanism of the stress etiologic factor. When occlusal forces and overloads are placed outside the axial direction of the teeth, they cause higher tooth deflection (Dejak et al., 2005). Consequently, microfractures can appear in mineralized tissues, if the stress values exceed those of their maximum resistance to tensile or compression (Bernhardt et al., 2006; Dejak et al., 2005). This occurs due to the breaking of bonds between the hydroxyapatite crystals present in the dental structure, making this area more susceptible to the other etiological factors of NCCL (Vasudeva & Bogra, 2008).

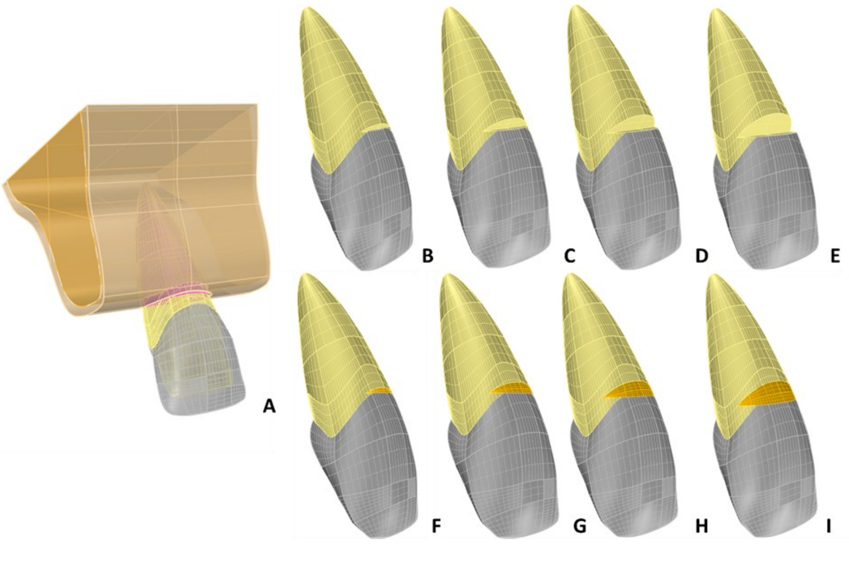
Considering the multifactorial etiology, the management of patients with NCCL includes several analyses and it is important to contain the progression of wear severity (Wood et al., 2008). Although there is no consensus or protocol established in the literature for these cases, some aspects should be analyzed, such as occlusal balance, parafunctional, occupational and dietary habits, physiological systemic changes and the restoration of the lesion should be performed (Kim et al., 2009). The restorative of NCCL is indicated because it provides, to the affected tooth, similar biomechanical behavior to sound tooth (Aw et al., 2002), and it also acts as a barrier to friction and biocorrosion and acts as an obliterating agent for cases of dentin hypersensitivity (Kim et al., 2009; Michael et al., 2009). Moreover, the most suitable material for this procedure is the composite resin (CR) (Machado et al., 2017; Peumans et al., 2014; Santos et al., 2014). However, CR is also susceptible to the etiological factors of NCCL, which can interfere with its longitudinal performance and favor early failure (Heymann et al., 1991; Powell et al., 1995).

Even with the information available in the scientific literature information about the NCCL, there are still gaps in the literature on the distribution of stress during the progression of the lesions and on the restorative procedure with CR for different depths of wear. Thus, the present study aims to evaluate the influence of the severity of the NCCL, at different levels of depth, and the restorations of these models on the biomechanical behavior and on the predictability of failure of the dental structures. The null hypothesis is that the type of load, the depth of the NCCL and the presence of restoration do not interfere on stress pattern and failure predictability.

2. Methodology

Three-dimensional linear elastic finite element analysis (FEA) was performed using anatomically based geometric representations for pulp, dentin, enamel, periodontal ligament, and cortical and medullary bones (Soares et al., 2013). Ten models were generated (Rhinoceros 3D software, Rhinoceros, Miami, FL, USA) simulating sound tooth (SO), and a tooth with NCCL unrestored (NR) different levels of depth (0.5 mm, 1.0 mm, 1.5 mm and 2.0 mm); beyond these respective depth's models restored with CR (Figure 1).

Figure 1. Preprocessing of the CAD model of a healthy upper central incisor. A- Volume of the structures of the sound model made in the modeling software. B, C, D and E- Models with NCCL with depth level of 0.5mm, 1.0mm, 1.5mm and 2.0mm respectively. F, G, H and I- Models with their respective NCCL restored.



Source: Data obtained by the authors.

In the processing of analysis, the models were export to a FEA software (ANSYS 12.0, Ansys Workbench 12.0.1, Canonsburg, PA, USA) using the Standard for Exchange of Product Data (STEP) format. The following steps were performed on this software: pre-processing (definition of mechanical properties, volumes, connection types, mesh for each structure, and boundary conditions), processing (data calculation), and post-processing (analysis of results by stress distribution and fatigue criteria). Enamel and dentin were considered orthotropic and the other structures isotropic (Table 1) (Carter & Hayes, 1977; Kuroe et al., 2000; Miura et al., 2009; Rubin et al., 1983; Weinstein et al., 1980).

Table 1. Mechanical properties used to perform orthotropic and isotropic structures.

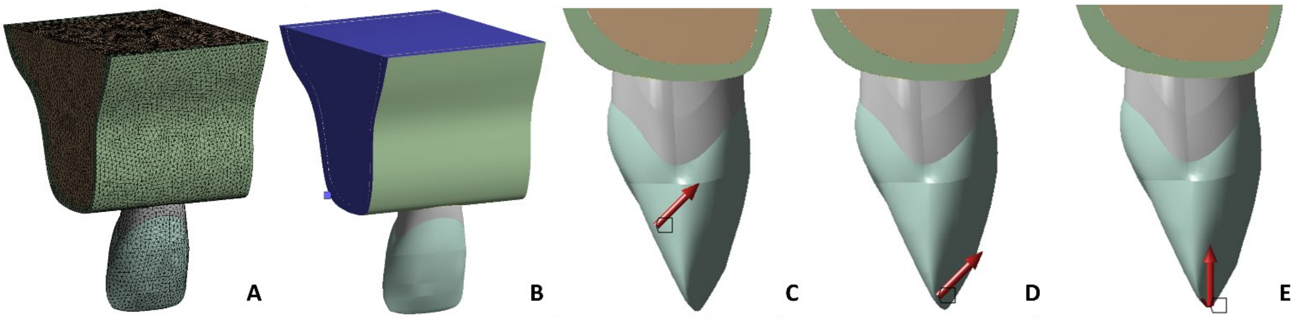
Structures	**Orthotropic Structures (Miura et al., 2009)**		
	Elastic Modulus (MPa)		
	LONGITUDINAL	**TRANSVERSAL**	**Z**
Enamel	73720	63270	63270
Dentin	17070	5610	5610
	Shear coefficient (MPa)		
Enamel	20890	24070	20890
Dentin	1700	6000	1700
	Poisson Ratio (v)		
Enamel	0.23	0.45	0.23
Dentin	0.30	0.33	0.30
Structures	**Isotropic Structures**		
	Elastic Modulus (MPa)	**Poisson Ratio (v)**	
Pulp (Rubin et al., 1983)	2.07	0.45	
Periodontal Ligament (Miura et al., 2009)	68.9	0.45	
Cortical Bone (Carter & Hayes, 1977)	13700	0.30	
Medullar Bone (Carter & Hayes, 1977)	1370	0.30	
Composite Resin (Kuroe et al., 2000)	14900	0.24	

Source: Data obtained by the authors.

Subsequently to the testing of mesh conversion to defined the appropriate mesh refinement level, volumes corresponding to each structure were meshed with controlled and connected elements. The meshing process involved division of the studied system into a set of small discrete elements defined by nodes. Solid quadratic elements of 10 nodes were used. The mesh conversion teste was initiated using the software automatic meshing and was continued by gradually decreasing the size of the elements. For each teste stage, the results were generated by von Mises criterion to verify the higher stress values in dentin. The mesh was considered satisfactory when, even reducing the dimension of elements, the higher stress levels were similar to the result observed with the previous mesh refinement. The number of elements used varied depending of the different volumes, so that the final model accurately represented the original geometry. Due to the adhesive properties of composite resin and adhesive system, the restoration was bonded to enamel and dentin by considering a mesh connection with dentin and enamel.

After the mesh step, boundary conditions were determined. The models underwent three types of loads (100N) applied on specific surfaces, previously defined in CAD Software. The loads simulated incisal movement and were applied at 45 degrees to the surface in the palatine middle third (PMT), on palatal incisal third (PIT) and axial to the long axis of the tooth for the incisal edge (IE). The models were constrained on the lateral and base of cortical and trabecular bone to avoid the displacement (Figure 2).

Figure 2. A- Mesh of solids with 10-nodes tetrahedral elements. B- Restriction of displacement on the lateral mesial, distal and base sides of the cortical and medullary bone. In the blue area, the offset is zero. C, D and E- Application of 100N loading in the palatal middle third (PMT), palatal incisal third (PIT) and incisal edge (IE) respectively.



Source: Data obtained by the authors.

After processing and generating linear and static results, the models were subjected to post-processing using mechanical material fatigue laws (Ausiello et al., 2011) to simulate mechanical aging. In this way, the software was provided with information regarding the intensity of stress necessary to promote the failure of enamel and dentin according to the number of cycles. The fatigue process was performed by calculating the number of cycles required for fatigue failure in a multi-axial manner and with a cyclic load. This was based on uni-axial linear elastic analysis for enamel and dentin, and calculated according to the following formula: $\sigma a = (\sigma f - \sigma m) \cdot (2Nf)^b$, where σa is the stress required to generate the failure; σf is the fatigue strength coefficient; σm is the main stress; Nf is the number of cycles required for the failure; and b is the exponent of fatigue strength. In the present study, the main stress is considered equal to 0, therefore, the cycles for fatigue simulation are considered totally reversed (σm = 0). According to the properties of enamel and dentin (Table 2) (Ausiello et al., 2011; Versluis & Versluis-Tantbirojn, 2011), the stress required to generate the failure (σa) was calculated considering from 1 to 10 million cycles (240,000 cycles correspond to 12 months of clinical simulation) and these data are inserted in the finite element software.

Table 2. Mechanical properties inserted in the software to promote the analysis of mechanical fatigue.

Properties	Enamel	Dentine
Fatigue strength coefficient (MPa) – σf (Ausiello et al., 2011)	**310**	**247**
Fatigue resistance exponent – b (Ausiello et al., 2011)	**-0.111**	**-0.111**
Maximum tensile strength (MPa) (Versluis & Versluis-Tantbirojn, 2011)	**10.3**	**98,7**
Maximum compressive strength (MPa) (Versluis & Versluis-Tantbirojn, 2011)	**384.0**	**297.0**

Source: Data obtained by the authors.

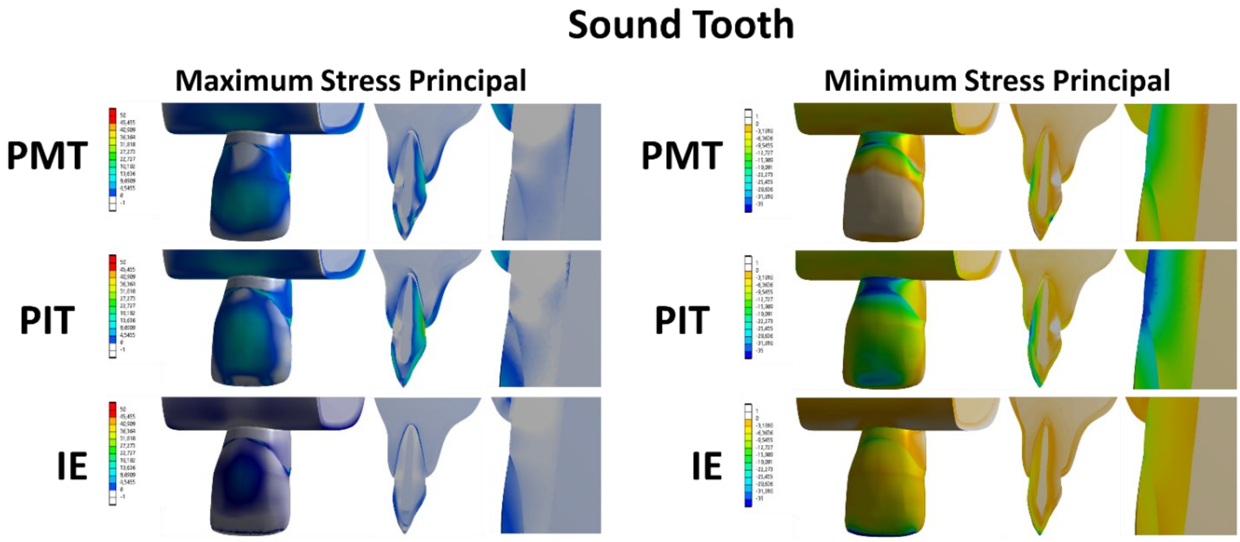
The stress distribution analyses were recorded using the Maximum and Minimum Principal Stress criteria, measured in MPa. For the 3D images perspectives, the composite resin was plotted in transparency for better understanding of the NCCLs walls. On the sagittal analyses, the composite resin was plotted to identify the stress on the restorative material.

3. Results

The results for stress distribution are plotted in Maximum Principal Stress and Minimum Principal Stress and Fatigue Life.

For the sound model, a higher compressive stress was noted in the cervical area, for PIT and PMT respectively. IE showed the lowest compressive stress for buccal cervical region (Figure 3). All models showed lower tensile stress values (Figure 4). However, it is worth mentioning that where the areas are in white color for the Maximum Principal Stress, it is due to the high concentration of compression stress.

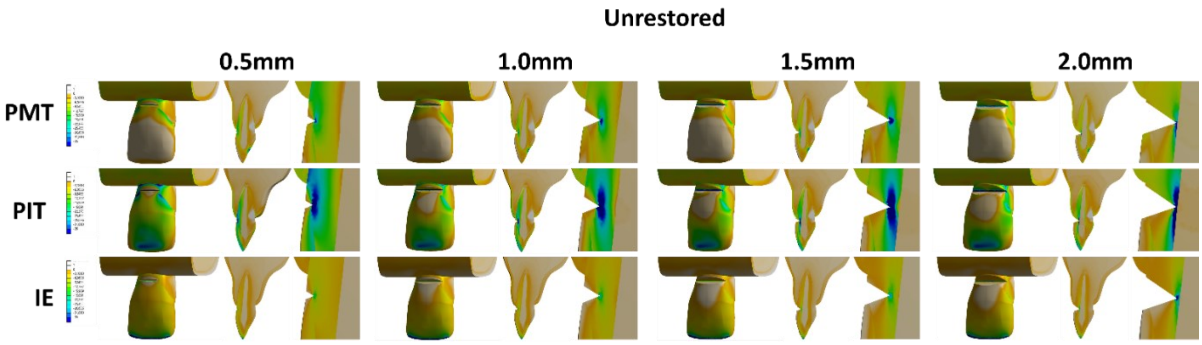
Figure 3. Analysis of the stress distribution pattern using the Maximum and Minimum Principal Stress (MPa) criterion. To Maximum Principal Stress the negative values (white color) represent the absence of tensile stress and positive values (closer to red) represent the maximum tensile values. To Minimum Principal Stress the positive values (white color) represent the absence of compression stress and the negative values (closer to the dark blue) represent the maximum compression values.



Source: Data obtained by the authors.

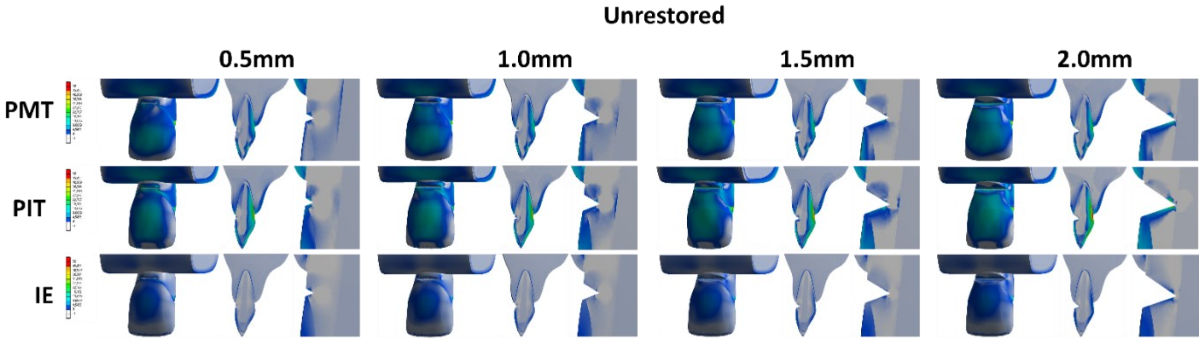
The loss of structure in the cervical area and the severity of NCCL was a determining factor for stress pattern. PIT and PMT showed a higher compressive stress in the NCCL, especially in lesions with greater depth (Figure 4). Lower values of compressive stress were observed for IE loading, but this had an increase in lesions of greater depth (Figure 4). In all loads and severity of lesions was observed a lower tensile stress values on NCCL's bottom. However, PIT showed higher tensile stress on the NCCL's walls (Figure 5). All the restored models, showed a similar pattern to the sound models, regardless of the lesion's depth and loading direction (Figure 6-7).

Figure 4. Analysis of the stress distribution pattern using the Minimum Principal Stress (MPa) criterion. The positive values (white color) represent the absence of compression stress and the negative values (closer to the dark blue) represent the maximum compression values.



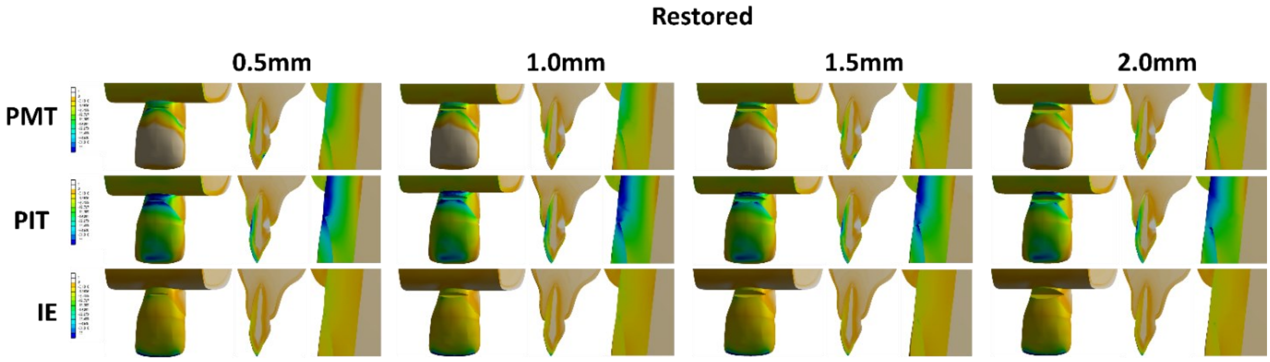
Source: Data obtained by the authors.

Figure 5. Analysis of the stress distribution pattern using the Maximum Principal Stress (MPa) criterion. Negative values (white color) represent the absence of tensile stress and positive values (closer to red) represent the maximum tensile values.



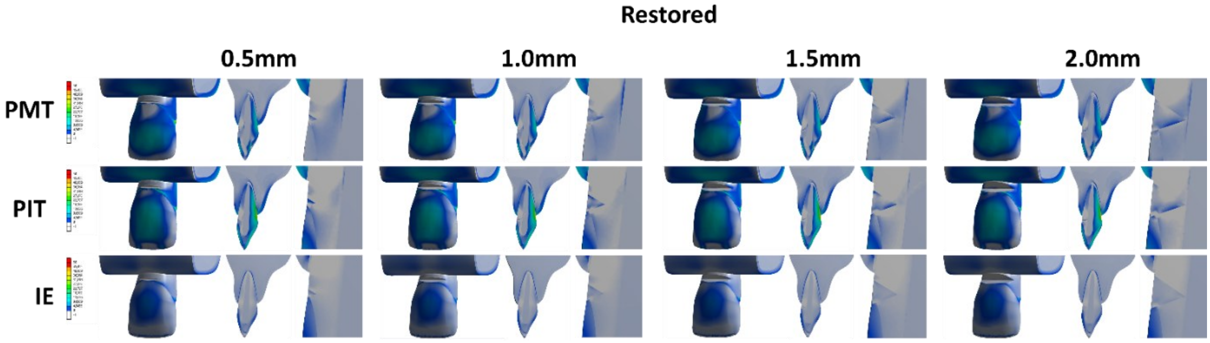
Source: Data obtained by the authors.

Figure 6. Analysis of the stress distribution pattern using the Minimum Principal Stress (MPa) criterion. The positive values (white color) represent the absence of compression stress and the negative values (closer to the dark blue) represent the maximum compression values.



Source: Data obtained by the authors.

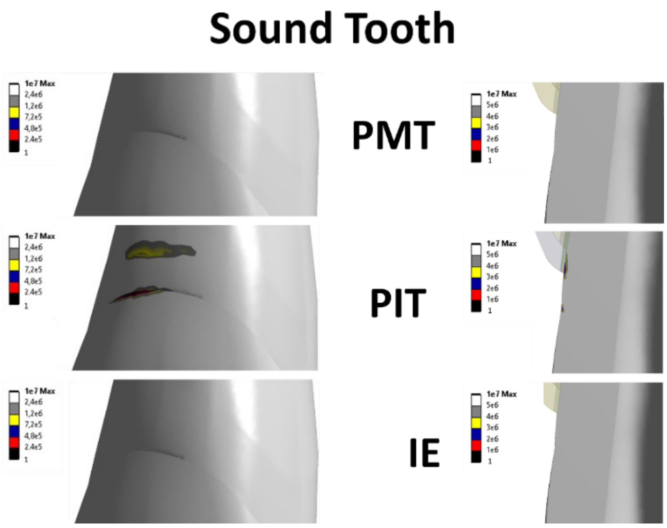
Figure 7. Analysis of the stress distribution pattern using the Maximum Principal Stress (MPa) criterion. Negative values (white color) represent the absence of tensile stress and positive values (closer to red) represent the maximum tensile values.



Source: Data obtained by the authors.

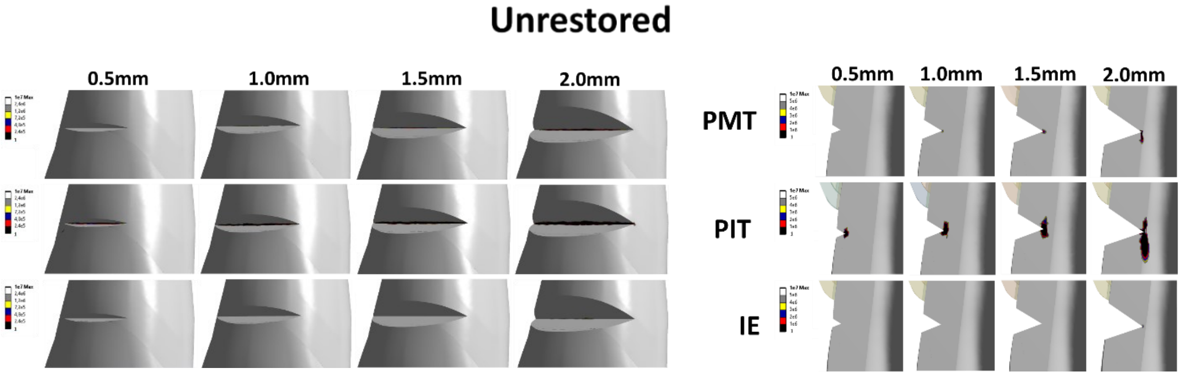
For mechanical fatigue analyzed by the survival criterion, the sound models associated with PIT was the only contact that resulted in a higher probability of failure of the dental structure in the near of cement-junction and bone crest (Figure 8). NR models with PIT and PMT showed a higher probability of failure of dental structure on the bottom of NCCL, and it increases as the progression of lesions (Figure 9). For the R models, the fatigue pattern was similar to the healthy models and PIT load showed a lower damaging effect on the vestibular bone crest region in the lesion restored whit a greater depth (Figure 10).

Figure 8. Analysis of the survival criterion pattern for enamel and dentin. The values mean the number of cycles that the structure must receive to fail, being represented by the respective colors.



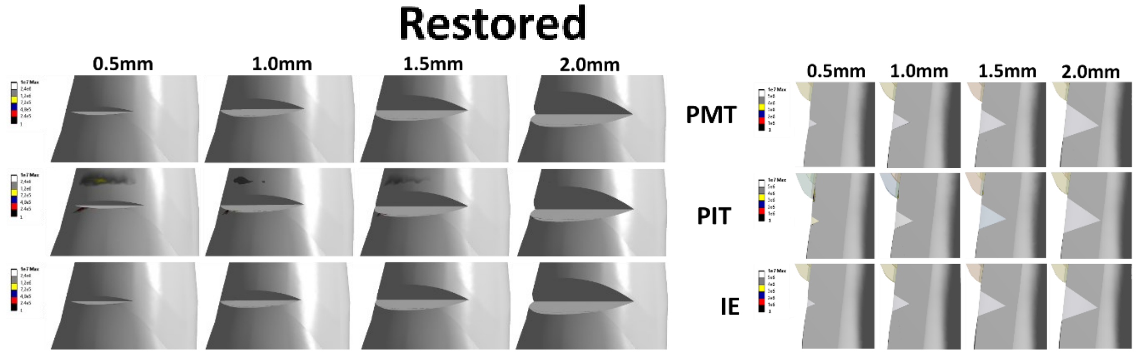
Source: Data obtained by the authors.

Figure 9. Analysis of the survival criterion pattern for enamel and dentin. The values mean the number of cycles that the structure must receive to fail, being represented by the respective colors.



Source: Data obtained by the authors.

Figure 10. Analysis of the survival criterion pattern for enamel and dentin. The values mean the number of cycles that the structure must receive to fail, being represented by the respective colors.



Source: Data obtained by the authors.

4. Discussion

Analyzing the results obtained by the finite element analysis, it was possible to observe, that the type of loading, the severity of NCCL and the restoration with composite resin influenced the pattern of stress distribution and the fatigue of the dental structure. Thus, the null hypothesis was rejected.

Regarding the main results of biomechanical behavior, TIP loading proved to concentrate greater stress, followed by TMP. It is in consistent with other studies that addressed the issue of oblique loading presenting greater stress on dental structures (Brandini, Pedrini, et al., 2012; I. Ichim et al., 2007; I. P. Ichim et al., 2007; Rees, 2002; Soares et al., 2014). As for the Maximum Principal Stress, whose reference is the tensile stress dissipated by the structure, it presented homogeneity in the models, except for those that received TIP loading, corroborating the potential for damage of this type of loading. The Minimum Principal Stress, referring to the compression, was more significant in all models and may be strongly related to the progression of NCCL.

Furthermore, the main data extracted from the fatigue-survival criterion were the relationships between the groups of unrestored (NR) and restored (R) models. For NR, the greater is the severity of the lesion, the shorter is the survival of the tooth structure, mainly coinciding with the models that had greater compression stress. However, for R models with TIP loading, it was observed that in the dental structure close to the bone crest region, the greater is the depth of the restored lesion, the lower is the failure predictability. This is because the modulus of elasticity of the composite resin used in this study is lower compared to the enamel and dentin, that would be present in a sound tooth (Table 1). So, this a factor that contributes to increasing the deflection of tooth structure, consequently favoring the stress dissipation in the cervical region.

The location and length of mechanical fatigue also provided relevant evidence. For NR models, this parameter was concentrated internally to the tooth and close to the NCCL. In addition, there was an increase in the stress concentration proportional to the increase in severity, with an apical-coronary projection of this area, more accentuated in the coronary direction, especially at the depth of 2mm. Observing this direct proportion between the severity of the NCCL and the fatigue area, this may be associated with the progression of wear over time, with predictability of structure failure in the early stages (Lee & Eakle, 1984; Rees, 2002) and being intensified, gradually, in the most advanced stages of the NCCL. The intensity of these factors can be unfavorable even in the case of less extensive fatigued areas, since the presence of more intense zones generates a greater reduction in the amount of cycles supported before the structure fails, given that about 240,000 cycles are equivalent to 12 months of clinical activity (Machado et al., 2017).

As for the R models, mechanical fatigue was concentrated on the dental surface in the subgingival cervical region, which may be compatible with data on dental surface defects associated with gingival recession, whose research resulted in approximately 53% association of this periodontal condition with subgingival NCCL (Pini-Prato et al., 2010). The increase in the depth of the restored NCCLs showed a relationship with the stress dissipation and a decrease in the failure predictability. At lower depths, there was greater length and stress concentration, being significantly dissipated at greater depths. In this group, the presence of a specific fatigue located immediately after the restoration in the cervical-incisal direction was also observed. In addition, the sound tooth models showed greater and more intense subgingival involvement than in the R group. From the analysis of these data, the presence of subgingival dentinal hypersensitivity represents a clinical possibility for patients with sound teeth or restored NCCL, but that still did not receive treatment for unbalanced occlusal contacts or other related pathological factors (Brandini, Trevisan, et al., 2012; Michael et al., 2009; Teixeira et al., 2018).

Despite the fact that the stress factor mechanism was considered unrelated to occlusal factors by some authors (Senna et al., 2012; Silva et al., 2013), it is currently a relationship confirmed by several studies, especially with regard to parafunctional habits, bruxism, malocclusions and even physiological mandibular movements, such as protrusion (Brandini, Trevisan, et al., 2012; Lee & Eakle, 1984). These loads on the teeth can take different directions, impairing the homogeneous stress distribution on the long axis, promoting concentration points and, consequently, generating areas of fatigue that reflect in the reduction of the structure's survival. Thus, the joint action of the other etiologies of non-carious lesions, friction and biocorrosion, aggravates the progression of NCCL even more (Grippo et al., 2012), especially after previous wear, which exposes the tissues of the cervical region, and these are already more susceptible due to their thickness and greater friability (Giannini et al., 2004; Hariri et al., 2012; Miura et al., 2009).

The loadings applied in this study are constituents of the physiological protrusion movement, both TIP and TMP being responsible for the oblique forces generated in the upper incisors (Machado et al., 2018; Poiate et al., 2009). Loading IE, on the other hand, features a vertical force distributed on the long axis of the tooth (Machado et al., 2018; Poiate et al., 2009) and perceived at the end of the protrusion movement, especially when patients perform it and remain in the edge-to-edge contact position between the incisors, as in some bruxism cases, dental clenching and habits of nail biting, incising objects, among other situations. Thus, the management of these cases involves a multidisciplinary approach (Michael et al., 2009) to act on the causes, whether they are psychological, physical, occupational or nutrition related, and the consequences, which may cause myofascial pain, periodontal damage, tooth wear, impair daily performance or even self-esteem.

As for the dental approach, it follows the recommendation to use adhesive materials with optical properties similar to those of the dental structure (Machado et al., 2017). The composite resin has characteristics similar to those of dentin, apart from attributing biomechanical behavior similar to the sound tooth, it also serves as a barrier to the other etiological factors of NCCL and reduces cervical dentin hypersensitivity (Kim et al., 2009; Michael et al., 2009), being the most recommended material (Machado et al., 2017; Peumans et al., 2014; Santos et al., 2014). In addition to the restorative procedure, occlusal adjustment must be performed to eliminate occlusal interference and dental contacts that pathologically influence the pattern of stress distribution (Kim et al., 2009).

Thereby, the results of the present study may corroborate the importance of the NCCL treatment, since its progression and advanced degrees of severity increase the predictability of tooth failure due to the generation of fatigued areas, especially in the cervical region. Additionally to that, the composite resin demonstrated efficacy in the rehabilitation of this condition, making the stress distribution more homogeneous. However, the absence of the action of the other etiological factors together with the precision of the values of the properties applied to the virtual models were considered limitations in the study development, since the complexity of the studied phenomena is greater in practice and may have more variations.

5. Conclusion

Therefore, within the methodological limitations of the present study, it can be concluded that the presence of non-axial contacts (PIT and PMT) associated with more severe NCCL were able to promote a higher concentration of compressive stresses in the tooth structure and possibly greater damage to the cervical tooth structure. The NCCL restoration proved to be effective in repairing the more homogeneous stress distribution pattern. Therefore, these contacts are part of physiological movements, but are intensified in parafunctional habits, requiring patient guidance, aiming to reduce the possibility of origin and progression of NCCL.

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Anexos

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