UNIVERSIDADE EVANGÉLICA DE GOIÁS
PROGRAMA DE PÓS-GRADUAÇÃO EM ODONTOLOGIA

GABRYELA NASCIMENTO CANEDO

EFEITO DO REMANESCENTE CORONÁRIO, TIPO DE PREPARO E MATERIAL RESTAURADOR NO COMPORTAMENTO DE ENDOCROWNS EM DENTES ANTERIORES: UMA ANÁLISE POR ELEMENTOS FINITOS

Anápolis

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Dissertação apresentada ao Programa de Pós-graduação em Odontologia, da Universidade Evangélica de Goiás – UniEVANGÉLICA como requisito para obtenção do título de mestre em Odontologia no Programa de Pós-graduação em Odontologia, Área de Concentração: Clínica Odontológica.

Orientadora: Profª. Drª. Priscilla Cardoso Lazari-Carvalho

Co-Orientador: Prof. Dr. Marco Aurélio de Carvalho

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Catalogação na Fonte

Elaborado por Rosilene Monteiro da Silva CRB1/3038

UNIVERSIDADE EVANGÉLICA DE GOIÁS - UniEVANGÉLICA
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ATA DA SESSÃO DE JULGAMENTO DO EXAME
DE DEFESA DE MESTRADO
GABRYELA NASCIMENTO CANEDO

Aos 25 dias do mês de julho de dois mil e vinte e quatro às 15 horas, realizou-se a sessão de julgamento do exame de Defesa da discente Gabryela Nascimento Canedo, com a dissertação intitulada EFEITO DO REMANESCENTE CORONÁRIO, TIPO DE PREPARO E MATERIAL NO COMPORTAMENTO MECÂNICO DE ENDOCROWNS EM DENTES ANTERIORES: UMA ANÁLISE POR ELEMENTOS FINITOS. A Banca Examinadora foi composta conforme Portaria nº. 15/2024 de 22 de julho de dois mil vinte e quatro pelos professores doutores: Priscilla Cardoso Lazari Carvalho (orientadora) Orlando Aguirre Guedes (Examinador Interno), Tales Candido Garcia da Silva (Examinador Externo) e Helder Fernandes de Oliveira (Suplente). A discente apresentou o trabalho, os examinadores a arguiram e ela respondeu às arguições, bem como participou da discussão durante a Defesa. Às 17:25 horas a Banca Examinadora passou a julgamento em sessão secreta, atribuindo a discente o seguinte resultado:

Linha de Pesquisa: **Técnicas, Materiais e Substâncias de Aplicação Clínica e Laboratorial em Odontologia**

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Prof. Dr. Tales Candido Garcia da Silva / Avaliador Externo / UNILAGO

Reaberta a sessão pública, a presidente da Banca Examinadora Dra. Priscilla Cardoso Lazari Carvalho proclamou os resultados e encerrou a sessão, da qual foi lavrada a presente a que vai assinada por mim, Michelle Rosa Assunção Borges, secretária e pelos membros da Banca Examinadora.

DEDICATÓRIA

A Deus por me permitir chegar até aqui me dando coragem, saúde e força. Por iluminar a minha caminhada e me agraciar com pessoas especiais que me ajudam a alcançar os meus objetivos.

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EPÍGRAFE

A força não provém da capacidade física. Provém de uma vontade indomável.

Mahatma Gandhi

SUMÁRIO

RESUMO

As endocrowns surgiram como uma alternativa ao método tradicional de pino e núcleo para restauração de dentes tratados endodonticamente, mas não existe um método definido para realizá-las. Portanto, o objetivo deste trabalho foi avaliar o comportamento biomecânico de restaurações do tipo endocrown em incisivos centrais tratados endodonticamente utilizando o método tridimensional dos elementos finitos. Os fatores de estudo foram a presença de férula (F: 2mm ou Nf: ausente), o tipo de preparo interno da raiz (2, 3 ou 4mm de profundidade) e o material da endocrown (D: dissilicato de lítio ou R: resina nano cerâmica). As variáveis respostas foram tensão principal máxima (σmax) e deslocamentos (umax) no dente e na restauração. Doze modelos tridimensionais de um incisivo central superior direito tratado endodonticamente foram construídos usando um software de modelagem tridimensional. Uma restauração tipo endocrown foi criada sobre a raiz do dente. A carga foi aplicada obliquamente (30º) na borda incisal da endocrown, simulando contato entre arcos na posição de protrusão mandibular na magnitude de 300N. Dados de tensão principal máxima (σmax) e deslocamentos (umax) foram obtidos para todas as estruturas. Os grupos F4D (férula com 4mm de profundidade), Nf2D (sem férula com 2mm de profundidade) e Nf4D (sem férula com 4mm de profundidade) exibiram as maiores concentrações de tensões. Os menores valores foram encontrados nas endocrowns de resina nano cerâmicas sem férula. As tensões concentraram-se na interface entre a endocrown e a raiz. As endocrowns de dissilicato de lítio demonstraram níveis de tensão mais elevados em comparação com as endocrowns de resina nano cerâmica. As endocrowns de resina nanocerâmicas não exibiram diferenças significativas nos valores de tensão entre os diferentes tipos de preparação. O tipo de material teve efeito significativo, elevando o deslocamento nas endocrowns nano cerâmicas. A presença de férula não afetou os níveis de tensão na raiz. Uma altura de preparo intrarradicular de 4 mm resultou em maiores concentrações de tensão.

Palavras-chave: Dente tratado endodonticamente, *endocrown*, restauração cerâmica.

ABSTRACT

Endocrowns emerged as an alternative to the traditional post and core method for restoring endodontically treated teeth, but there is no defined method for performing them. Therefore, the objective of this work was to evaluate the mechanical behavior of endocrown-type restorations in endodontically treated central incisors using the three-dimensional finite element method. The study factors were the presence of ferrule (2mm or zero), the type of internal root preparation (2, 3, or 4mm), and the material (lithium disilicate or nanoceramic resin). The response variables were maximum principal stress (σ_{max}) and displacements (u_{max}) in the tooth and restoration. 12 three-dimensional models of an endodontically treated upper right central incisor were constructed using three-dimensional modeling software. An endocrown-type restoration was created over the root of the tooth. The load was applied obliquely (30º) on the incisal edge of the endocrown, simulating contact between arches in the mandibular protrusion position at a magnitude of 300N. Data on maximum principal stress (σ_{max}) and displacements (u_{max}) were obtained for all structures. The groups F4D (ferrule with 4mm depth), Nf2D (no ferrule with 2mm depth), and Nf4D (no ferrule with 4mm depth) exhibited the highest stress concentrations. The lowest values were found in Nanoceramic endocrowns without ferrule. The stresses were concentrated at the interface between the endocrown and the root. Lithium disilicate endocrowns demonstrated higher stress levels compared to nano ceramic endocrowns. Nanoceramic endocrowns did not exhibit significant differences in stress values across different preparation types. The type of the material has a significant effect, elevating the displacement in the nano ceramic endocrowns. The presence of a ferrule did not affect the stress levels in the root for endocrown restorations. A 4mm intraradicular preparation height resulted in higher stress concentrations. Nanoceramic resin demonstrated lower stress concentrations compared to other materials.

Keywords: endodontically treated teeth, endocrown, ceramics.

INTRODUÇÃO

Restaurar dentes que passaram por tratamento endodôntico exige atenção meticulosa, sobretudo por conta da sobrevivência incerta a longo prazo, que depende significativamente da quantidade e qualidade da estrutura dentária remanescente (1–4). Os dentes tratados endodonticamente (DTE) apresentam um risco maior de fratura quando comparado aos dentes vitais (5–7), isso acontece, pois, a tensão induzida no dente é diretamente proporcional à resistência à fratura e ao volume da estrutura dental remanescente (8).

Convencionalmente, um sistema núcleo e coroa, com ou sem retentor intraradicular, geralmente é a técnica mais utilizada para a restauração desses dentes (9). Os retentores intracanais são amplamente utilizados e ajudam a promover a retenção do núcleo para que seja feita então a cimentação da coroa, sendo que o retentor não atua no aumento ou melhora da resistência do dente (10). No entanto, uma revisão recente da literatura mostrou que não houve diferença na resistência à fratura ou sobrevivência de DTE com e sem pinos intrarradiculares e que o risco de falha foi favorável quando utilizado os de pinos intrarradiculares (3). Além disso, o uso de pinos intraradiculares foi responsável por falhas radiculares catastróficas, que levariam à necessidade de extração dos dentes em estudos in vitro (11–14).

Com a popularização das técnicas adesivas, a melhora dos materiais odontológicos e principalmente o advento da tecnologia CAD/CAM, tornou-se comum restaurar dentes com extensa destruição coronária sem o uso de pinos intraradiculares, fazendo o uso da extensão da câmara pulpar como área de retenção da restauração (15,16). Pissis (1995) foi o precursor desta técnica, descrevendo-a como “técnica de porcelana monobloco”. Posteriormente a técnica foi chamda de “*endocrown*” e foi descrita pela primeira vez por Bindl e Mormann em 1999 (15) como coroas endodônticas adesivas, caracterizando-as como coroas totais de porcelana para dentes despolpados posteriores. Essas coroas eram ancoradas na parte interna da câmara pulpar e nas margens da cavidade, obtendo-se a retenção mecânica fornecida pelas paredes do canal radicular e pelo uso de cimentação. Esta técnica é de fácil execução, demanda menos tempo clínico em comparação com coroas convencionais, possui menor custo devido ao menor número de passos envolvidos, e tem boa aceitação estética (18–21).

Apesar do seu uso em dentes posteriores datarem quase 30 anos, sua indicação em dentes anteriores ainda é um desafio. As restaurações utilizadas em dentes anteriores estão sujeitas a grandes momentos de flexão, conforme ditado pelos princípios de alavanca (22). Além disso, os dentes anteriores possuem uma área de superfície disponível para colagem menor quando comparados com os dentes posteriores (22). Essas características tornam o uso de endocrowns em incisivos mais complexos e desafiadores (23). Estudos tem demonstrado resultados satisfatórios quando comparadas com o uso de pinos ou núcleos resinosos (12), no entanto ainda existem dúvidas em relação a influência de alguns fatores na biomecânica do dente, tais como a influência do remanescente coronário associado as restaurações endocrown e qual o melhor tipo de preparo interno a ser realizado no dente.

Além disso, devido à posição do incisivo ser de destaque, uma ênfase maior na obtenção de uma estética naturalista agrava ainda mais este desafio.

Consequentemente, a situação exige a seleção de materiais de coroa capaz de suportar níveis substanciais de tensão sem comprometer o apelo estético. Exemplos incluem o dissilicato de lítio e as resinas nano cerâmicas, conhecidos por sua resiliência e propriedades estéticas excepcionais (24,25).

Embora diversas técnicas de restauração de dentes endodonticamente tratados e com extensa destruição coronária em diferentes situações clínicas sejam empregadas com relativa frequência, uma busca na literatura científica não revelou a existência de estudos que comparassem o desempenho mecânico de dentes anteriores restaurados por diferentes configurações e tipo de material de *endocrowns* em incisivos que apresentam ou não remanescente coronário. Desta forma, o estudo dessas técnicas poderia contribuir para o estabelecimento de bases científicas para padronizar os tipos de preparo e indicar o melhor tipo de material restaurador. O objetivo desse trabalho foi avaliar o comportamento biomecânico de restaurações do tipo endocrown em incisivos centrais tratados endodonticamente através do método dos elementos finitos tridimensionais, variando a presença do remanescente coronário (com 2mm ou sem remanescente coronário), o tipo de preparo intraradicular (alturas de 2mm, 3mm ou 4mm) e o tipo de material (dissilicato de lítio ou resina nano cerâmica) na tensão principal máxima (σmax) e deslocamentos (umax) na raiz e coroa.

CAPÍTULO 1

Endocrowns: Evaluating the Impact of Different Designs on the Mechanical Behavior of Endodontically Treated Anterior Incisors

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ABSTRACT

Endocrowns emerged as an alternative to the traditional post and core method for restoring endodontically treated teeth, but there is no defined method for performing them. Therefore, the objective of this work was to evaluate the mechanical behavior of endocrown-type restorations in endodontically treated central incisors using the three-dimensional finite element method. The study factors were the presence of ferrule (2mm or zero), the type of internal root preparation (2, 3, or 4mm), and the material (lithium disilicate or nanoceramic resin). The response variables were maximum principal stress (σ_{max}) and displacements (u_{max}) in the tooth and restoration. 12 three-dimensional models of an endodontically treated upper right central incisor were constructed using three-dimensional modeling software. An endocrown-type restoration was created over the root of the tooth. The load was applied obliquely (30º) on the incisal edge of the endocrown, simulating contact between arches in the mandibular protrusion position at a magnitude of 300N. Data on maximum principal stress (σ_{max}) and displacements (u_{max}) were obtained for all structures. The groups F4D (ferrule with 4mm depth), Nf2D (no ferrule with 2mm depth), and Nf4D (no ferrule with 4mm depth) exhibited the highest stress concentrations. The lowest values were found in Nanoceramic endocrowns without ferrule. The stresses were concentrated at the interface between the endocrown and the root. Lithium disilicate endocrowns demonstrated higher stress levels compared to nano ceramic endocrowns. Nanoceramic endocrowns did not exhibit significant differences in stress values across different preparation types. The type of the material has a significant effect, elevating the displacement in the nano ceramic endocrowns. The presence of a ferrule did not affect the stress levels in the root for endocrown restorations. A 4mm intraradicular preparation height resulted in higher stress concentrations. Nanoceramic resin demonstrated lower stress concentrations compared to other materials.

Keywords: endodontically treated teeth, endocrown, ceramics.

INTRODUCTION

With the advent of adhesive dentistry, it became acceptable to restore teeth with extensive coronal destruction through restorations without the use of intracanal posts, using the entire extent of the pulp chamber as a retention area (1–3). The terminology “endocrown” was first described by Bindl and Mormann in 1999 (1) as adhesive endodontic crowns, characterized as full porcelain crowns for posterior endodontically treated teeth. These crowns were anchored inside the pulp chamber and at the cavity margins, thus obtaining mechanical retention provided by the canal walls and using adhesive procedures. This technique is easy to perform, demands less clinical time than conventional crowns, has lower costs due to fewer steps involved, and has good aesthetic acceptance (4).

Endocrowns are minimally invasive prostheses suitable for teeth with one or more conditions: short clinical crowns, inadequate inter-occlusal space, curved roots, small roots, and calcified root canals (5). The endocrown technique has shown adequate load-to-failure, marginal adaptation, and adhesion to dental tissues, and it can be a single-session procedure, which is an attractive feature for clinical practice (4,6–8).

Mandibular molars and maxillary premolars teeth were the most frequently teeth used in laboratory studies according to the literature, due to their anatomical size (9). They usually present a design with a 2 or 4-mm extension into the root (9). Studies on the use of endocrowns for the restoration of anterior teeth are limited. The resistance of this type of restoration may be associated with differences in the geometry of the root canal opening, as well as its height and the presence or absence of ferrule (10–13). The studies usually used a 4mm internal preparation (10–13) and the failure pattern was favorable to endocrowns when compared with intraradicular fiber posts (10–13). However, it seems there is no consensus on the most appropriate preparation type for anterior endocrowns (14).

In addition, the biomechanical properties of prosthetic material play a critical role in the success of post-endodontic restorations (15). Lithium-disilicate ceramic was the most used ceramic material (9). However, the use of ceramic materials with elastic moduli higher than dentin can result in tooth catastrophic fractures (16). The advancements in CAD/CAM (Computer-assisted Designing/Computer-assisted Manufacturing) technology have facilitated the utilization of novel restorative materials, characterized by enhanced esthetics, precise fit, and marginal accuracy (16).

Despite the rising popularity of endocrowns in dental restorations, their ability to fully replace conventional methods remains a topic of debate. This study aims to delve into the biomechanical behavior of endodontically treated maxillary incisors with endocrowns, focusing on several critical factors: the presence or absence of a ferrule, the height of the intraradicular preparation, and the type of restorative material used. Utilizing the three-dimensional finite element method, we seek to uncover how these variables impact stress values and distribution within the root and endocrowns. The null hypothesis conceives that neither the presence of a ferrule, the preparation height, nor the material type will significantly influence these stress parameters.

MATERIAL AND METHODS

Experimental Design

Three-dimensional models of an upper central incisor restored with the endocrown technique were used. The study factors were the presence or absence of 2-mm ferrule, height of the internal root preparation (2, 3, or 4mm), and type of restorative material (lithium disilicate (Ld) or nanoceramic resin (Nr)). The response variables were: Maximum principal stress (σmax) and maximum principal displacement (umax) for all structures involved.

3D modeling

A previous sample of a central incisor restored with a full crown was used as the primary model (17). The sample was constructed with a 15mm bovine root (in which 2mm was the ferrule effect), 0.8 mm deep reduction chamfer margin, 1.5 mm proximal wall width, and 5mm of core build-up. This root was scanned by an intra-oral scanner BlueCam (Cerec 3) and a lithium-disilicate crown with 11mm height and 9mm width was milled.

The sample (root, build-up, and crown) was scanned with a 3D scanning system (optical structured-light Scanner S600 ARTI, Zirkonzahn USA Inc) before and after the crown cementation. The surfaces were imported into the CAD software SolidWorks 2014 (Dassault Systèmes SolidWorks Corp) for geometry simplification and design refinement. Afterward, the endocrown restoration was constructed with three different intracanal heights (2, 3, or 4 mm). Additional Boolean operations with CAD objects were used to simulate a bone fixation base (embedding the root within 2.5mm of the cementoenamel junction), as well as different preparations (endodontic access, no-ferrule groups, and internal ferrule preparations) (18). The exact design and dimensions of the experimental conditions are described in Figure 1. Six models were created following the study factors as represented in Figure 2.

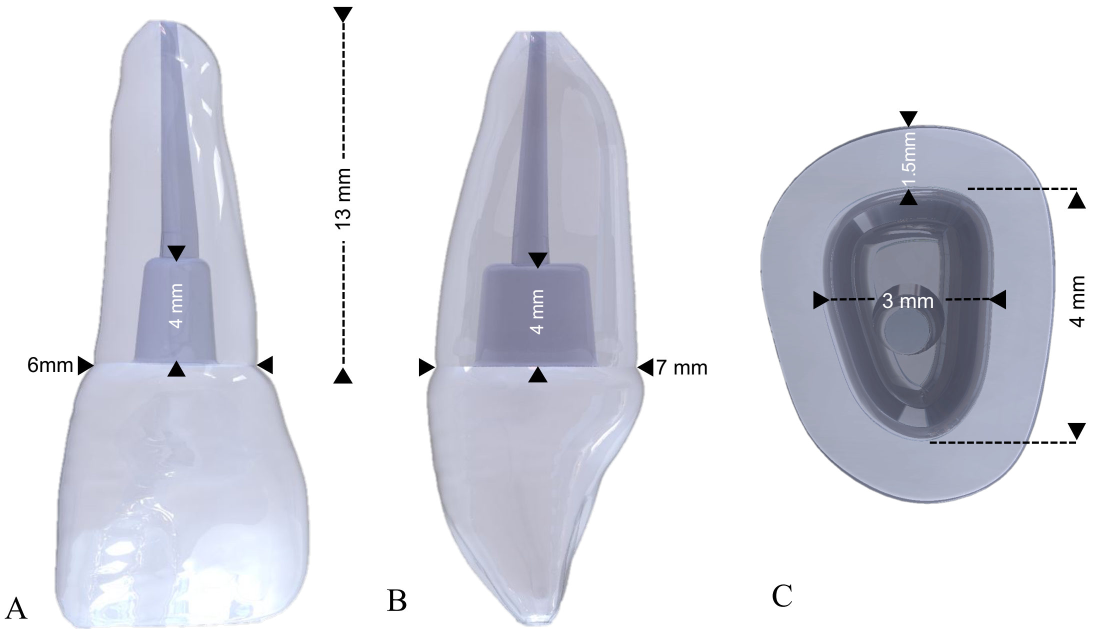

Figure 1: Schematic view of the exact dimensions of the experimental condition before the Boolean operations. A: buccal view, B: Lateral view, C: incisal view.

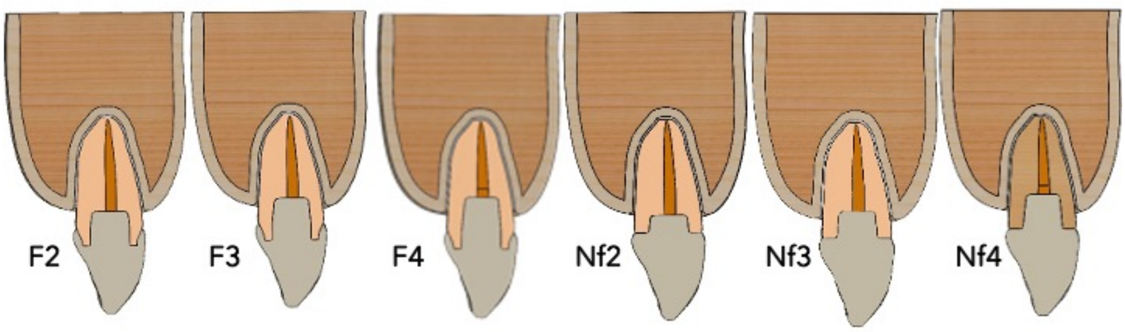

Figure 2: Six models created following the study factors. F: ferrule with 2, 3, or 4mm internal preparation. Nf: no-ferrule with 2, 3, or 4mm internal preparation.

Finite Element Analysis

The CAD models were imported to finite element analysis software (Ansys Workbench 14.0 FEA software, Swanson Analysis Inc) for the generation of a volumetric mesh and attribution of material properties. All structures were considered isotropic, homogeneous, and linearly elastic. Material properties such as the elastic modulus and Poisson ratio were obtained from the literature (Table 1). The mesh was constructed through convergence of analysis (5%), which was determined in all models by using a tetrahedral element of 0.5mm in size. Particular attention has been devoted to the refinement of the mesh resulting from the convergence tests at the external surface of the root.

Table 1. Mechanical properties of the materials.

	Elastic Modulus (GPa)	Poisson's Coefficient	References
Dentin	20	0,31	(19)
Periodontal ligament	0.0689	0,45	(20)
Gutta-percha	0.14	0,45	(21)
Lithium-disilicate	95	0,30	(22)
Nano ceramic resin (lava ultimate)	12.8	0,30	(22)
Cortical bone	13.9	0.3	(23)
Trabecular bone	0.259	0.3	(23)

All structures were taken as bonded. The models were defined by fixing the exterior surfaces of the bone in all directions. The models were loaded using a 300N applied to the incisor edge at an angle of 30 degrees from the long axis of the tooth (24) (Figure 3). The Maximum principal stress (σmax) was obtained for the root and endocrown. The maximum principal displacement (Umax) was observed only for the endocrowns.

Figure 3: 300N load applied to the incisor surface at an angle of 30 degrees from the long axis of the tooth.

RESULTS

Following the data processing by the finite element analysis program, stress distributions, and displacement were obtained for the roots and endocrowns (Figures 4 and 5). The Maximum Principal Stress values are detailed in Figure 6 and the displacement in Figure 7.

By comparing the different groups, it was found that the studied factors did ~~not significantly~~ impact the overall stress levels in the root, with stress values ranging from 52 to 58 MPa. However, a detailed analysis of stress distribution revealed notable variations among the groups, especially concerning lithium disilicate (Ld) endocrowns. The groups F4D (ferrule with 4mm depth), Nf2D (no ferrule with 2mm depth), and Nf4D (no ferrule with 4mm depth) exhibited the highest stress concentrations (Figure 4).

The type of internal preparation significantly influenced the stress distribution of the endocrowns restoration. The highest stress concentrations were observed in models with ferrule and a 4mm intraradicular preparation for Ld endocrowns. The lowest values were found in Nano ceramic endocrowns, also without ferrule. The stresses were concentrated at the interface between the endocrown and the root.

When evaluating the impact of material type on stress values, the most notable differences were observed in the crown. Lithium disilicate endocrowns demonstrated higher stress levels compared to nano ceramic endocrowns. Furthermore, the stress distribution patterns varied depending on the material used. For Ld endocrowns, the highest stress values were recorded in the 4mm preparations, indicating a potential correlation between preparation depth and stress concentration. In contrast, nanoceramic endocrowns did not exhibit significant differences in stress values across different preparation types.

On the contrary, when observing the displacement between groups, the type of the material has a significant effect, elevating the displacement in the nano ceramic endocrowns.

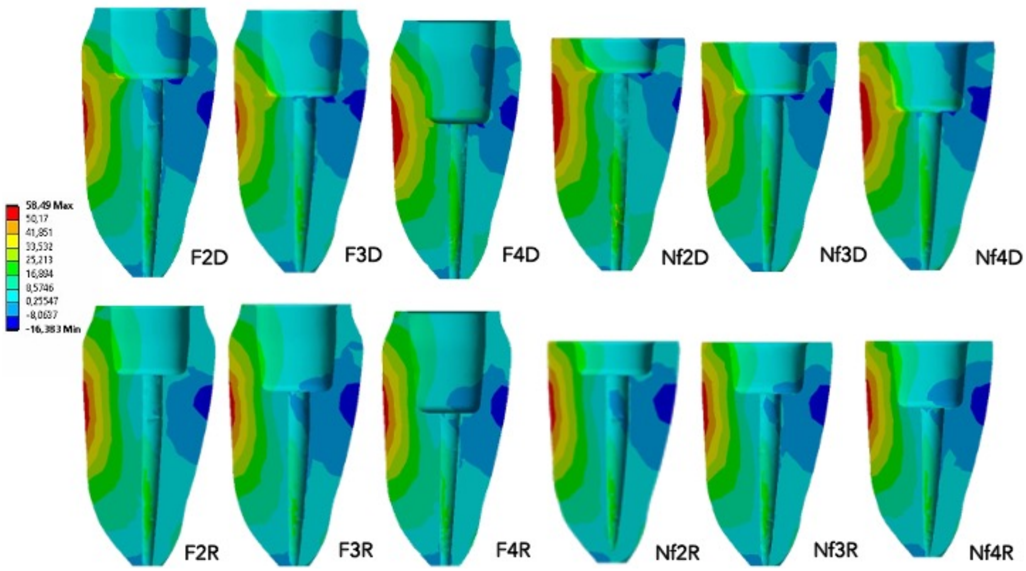

Figure 4: Maximum Principal Stress (Tensile - MPa) for the root. F: ferrule with 2, 3, or 4mm internal preparation. Nf: no-ferrule with 2, 3, or 4mm internal preparation. D: lithium-disilicate, R: Nano ceramic Resin

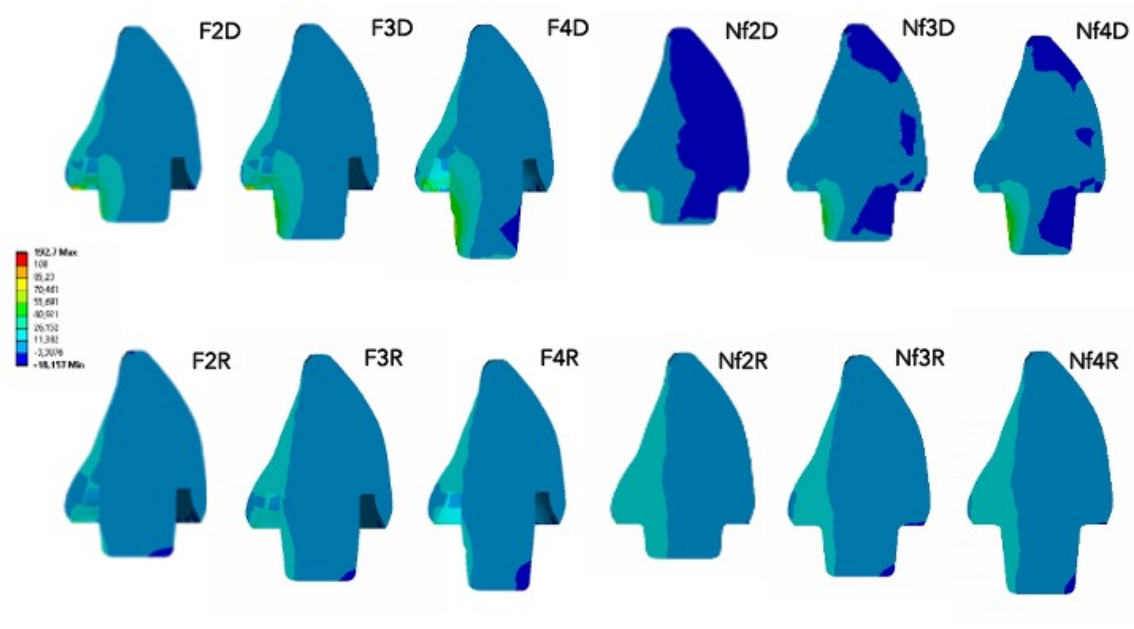

Figure 5: Maximum Principal Stress (Tensile - MPa) for the endocrown. F: ferrule with 2, 3, or 4mm internal preparation. Nf: no-ferrule with 2, 3, or 4mm internal preparation. D: lithium-disilicate, R: Nano ceramic Resin

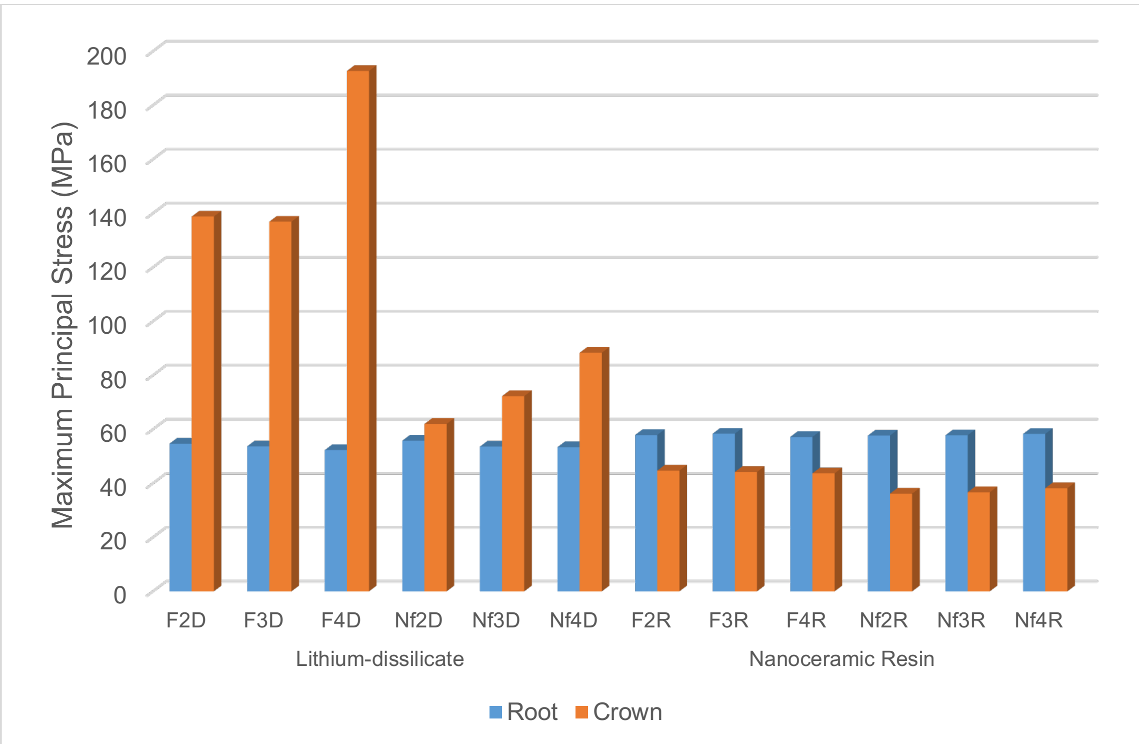

Figure 6: Maximum Principal Stress values for the root and endocrown.

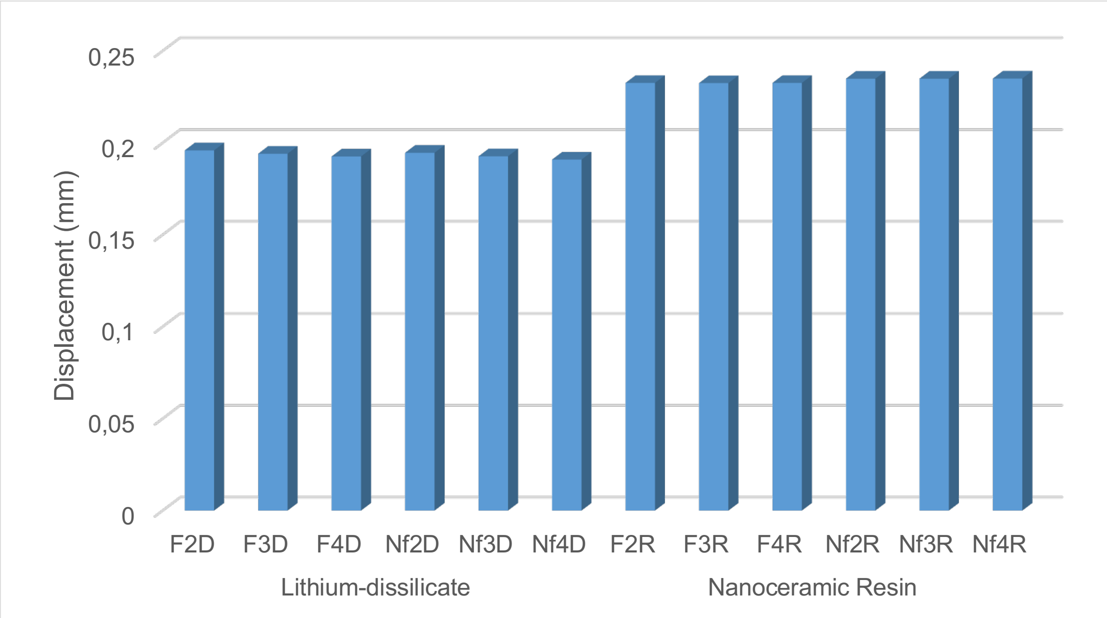

Figure 7: Displacement values for the endocrowns

DISCUSSION

The study aimed to evaluate the influence of a ferrule's presence or absence, the intraradicular preparation's height, and the type of restorative material on the biomechanical behavior of endodontically treated maxillary incisors with endocrowns. The null hypotheses of this study were rejected since the presence of a ferrule, the preparation height, and the material type influenced the mechanical behavior of anterior endodontically treated teeth.

Many directions regarding the best rehabilitation therapy involving endodontically treated teeth are based on static or dynamic fracture resistance tests. The choice to use a finite element analysis evaluation was due to the fact the FEA is a technology that has the advantage of controlling a single variable and limiting other variable factors and overcomes the limitation in physical research that it is difficult to isolate teeth that are identical in geometric form and tissue structure (25). Also, the same experimental design was used in an in vitro analysis and proved that endocrowns improved the resistance and optimized the failure mode compared to traditional bonded crowns with adhesive post-and-core and no-post buildups (3). Therefore, the stress distribution of each part of the model can be observed from any angle, helping to analyze the stress distribution more intuitively.

The presence of a ferrule is the most important factor in increasing the resistance of the endodontically treated incisors (26). It has been well-documented that a ferrule can provide additional resistance to fracture and improve the overall stability of the restoration (26–29). Besides most of the studies used endocrown for teeth without ferrule, the use of endocrown with ferrule effect appears to be feasible for the rehabilitation of anterior endodontically treated teeth (11). The results of the study showed that the effect of ferrule was only relevant for the stress in the endocrown restoration since the quantitative stress at the root did not change significantly with or without ferrule. Although there is no numerical difference, in the present study a greater area of stress can be observed in models with 4mm of preparation. This can explain the results found in the literature that showed that endocrowns without ferrule present more catastrophic failures compared to endocrowns with ferrule when a 4mm preparation height is used (11).

In cases where a ferrule is not present, careful consideration of the preparation depth and material choice becomes even more important. In the absence of a ferrule, as seen in the Nf2D and Nf4D groups, the stress concentrations tend to be higher, potentially increasing the risk of root fractures. The F4D group, despite having a ferrule, also showed high-stress concentrations, suggesting that other factors such as preparation depth and material properties play a significant role.

Appropriate endocrowns designs should balance the stress distribution in all parts of the tooth to avoid excessive local stress concentration, which may lead to complications such as fracture and detachment (25). Studies have shown that the depth of intraradicular preparation can significantly affect the mechanical behavior of endocrowns (30,31). A deeper preparation, such as 4mm, is the most used type of preparation and tends to distribute stress more evenly and reduce peak stress concentrations for molars (30). The results of the study showed the 4mm preparation increased the stress at the endocrown restoration significantly, showing the 3mm preparation can decrease the stress and keep enough area for adhesive procedures. Also, as mentioned before, endocrowns restorations are very commonly associated with CAD/CAM technology, and a deeper preparation can negatively affect scanning accuracy (32).

Material selection plays a crucial role in the performance of endocrowns (9). Lithium disilicate and nanoceramic resin are commonly used materials, each with distinct mechanical properties (9). Lithium disilicate is known for its high strength and esthetic qualities, while nanoceramic resin offers enhanced flexibility and shock absorption (3), which was observed in more displacement for Nr endocrowns. Using ceramic materials with elastic modulus higher than dentin resulted in tooth catastrophic fractures (16). In the present study, Ld endocrowns showed higher stress concentration than nano ceramic endocrowns however, Ld presents high strength and can receive a more load without fracture (31).

On the other hand, the resilient Nr material exhibits a lower incidence of catastrophic failures, potentially due to its superior stress distribution (3). This can be attributed to its lower elastic modulus, which may reduce stress concentration at the root compared to ceramic endocrowns (3). However, it is worth noting that another study in the literature reported catastrophic failure and reduced restorability for Nr endocrowns. It is crucial to highlight that the present findings indicated that the choice of material did not influence the stress experienced by the root, but rather affected the restoration itself.

In summary, the study underscores the importance of material selection and internal preparation type in influencing the stress distribution and displacement of endocrown restorations. Lithium disilicate endocrowns, particularly with deeper preparations, tend to exhibit higher stress concentrations, whereas nano ceramic endocrowns show more favorable stress distribution but increased displacement.

The choice between these materials should be guided by the specific clinical scenario and the desired balance between strength and resilience. In summary, optimizing the design and material of endocrowns is essential for achieving favorable stress distribution and ensuring the longevity of dental restorations. Clinicians must consider not only the overall stress levels but also the distribution of stress within the restoration to ensure long-term success and minimize complications. Further research and clinical trials continue to refine these parameters, contributing to improved outcomes in restorative dentistry.

CONCLUSION

Within the scope of finite element analysis, the conclusions of the study are that biomechanical behavior of endodontically treated teeth:

The presence of a ferrule did not significantly affect the stress levels in the root for endocrown restorations.

A 4mm intraradicular preparation height resulted in higher stress concentrations both in the root and within the endocrown restoration itself.

The type of material used for the endocrown significantly influenced the stress distribution within the restoration. Nanoceramic resin demonstrated lower stress concentrations compared to Lithium disilicate.

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CONSIDERAÇÕES FINAIS

Com base nas conclusões obtidas no estudo foi possível delinear as seguintes conclusões e suas implicações clínica. O estudo revelou que a presença da férula não teve um impacto significativo nos níveis de tensão na raiz de dentes tratados endodonticamente e restaurados com restaurações do tipo endocrown. Este resultado sugere que esse tipo de restauração pode ser usado em ambas as situações clínicas, permitindo uma maior flexibilidade na escolha da técnica restauradora.

Em relação a altura do preparo intraradicular observou-se que uma altura de preparo de 4mm resultou em maiores concentrações de tensão tanto na raiz quanto na própria restauração endocrown nos dentes restaurados com endocrowns de dissilicato de lítio. Este achado é crucial para a prática clínica, pois indica que preparos mais profundos podem aumentar o risco de falhas estruturais, além da dificuldade em se utilizar os scanners intraorais para escaneamento de preparos intraradiculares, sendo sugerido então preparos médios de 2 ou 3 mm de profundidade.

O tipo de material utilizado na confecção da endocrown teve uma influência significativa na distribuição de tensões dentro da restauração. Especificamente, a resina nano cerâmica demonstrou menores concentrações de tensão em comparação com outros materiais. Este resultado destaca a importância da seleção do material restaurador, sugerindo que a resina nano cerâmica pode ser uma escolha para reduzir o risco de falhas na restauração.

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