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Ceramic Endocrown vs Ceramic Onlay with Resin Core in Endodontically Treated Teeth: A Finite Element Analysis

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Resumo

Introdução: Os dentes não vitais apresentam certas características que os fragilizam, diminuindo deste modo a sua resistência. Esta fragilidade está intimamente ligada a perda de tecido dentário, que pode ser resultante de trauma, cárie ou mesmo na terapêutica endodôntica. Neste âmbito, no procedimento endodôntico pode haver a uma remoção aumentada de tecido dentário, não só na zona coronária aquando da execução de acesso coronário, mas também num acesso canalar direto ao 1/3 apical, podendo pode ser necessário proceder a remoção de dentina no 1/3 cervical radicular. Posto isto, a restauração deste tipo de dentes é altamente discutida na literatura, sendo que existem várias abordagens possíveis, dentro das quais as *Endocrowns* e os *Onlays*. Este estudo baseia-se numa análise de Elementos Finitos (EF) em modelo 3D de um primeiro prémolar maxilar.

Objetivos: O objectivo deste estudo é comparar, num modelo de EF a distribuição de stress entre duas possíveis abordagens para restauração de dentes com tratamento endodôntico, *Endocrown* ou *Onlay* com um build-up em resina composta.

Materiais e métodos: O modelo do prémolar com dois canais radiculares foi isolado, tendo sido feitos cortes de acordo com o tipo de cavidade necessária, com o objetivo de simular um dente com uma grande destruição coronária, apenas com a parede vestibular e canais obturados com guta-percha. Simulou-se posteriormente a restauração do dente com uma *Endocrown* totalmente cerâmica e com um *Onlay* cerâmico com um core em resina composta. Foram aplicadas três intensidades de força (200, 500 e 800 *Newtons*) com 2 inclinações diferentes (11º e 45º) em relação ao longo eixo do dente, na face oclusal do modelo com uma esfera metálica de 4 mm.

Resultados: Neste estudo foram comparadas as distribuições de stress e os valores máximos de stress no tecido dentário e nos materiais restauradores (esmalte, dentina, cerâmica e resina composta) e apenas no tecido dentário (esmalte e dentina). Foi possível observar uma maior concentração de stress em forças de maior intensidade com uma inclinação de 45º em ambos os modelos. A *Endocrown* obteve maiores valores de stress em todos os testes, excepto aquando da análise dos valores no esmalte e dentina com a aplicação da força a 11º.

Conclusões: Apesar das limitações deste estudo podemos concluir que forças com um ângulo de 45º com o longo eixo do dente geram maiores valores de stress no dente, comparando com forças a 11º. É possível também concluir que quando estas forças mais destrutivas são aplicadas, a restauração através de *Onlays* apresenta melhores resultados do que a restauração com *Endocrowns*.

Palavras-chave: *Endocrown* ; *Onlay* ; Elementos Finitos ; *Restodontics.*

Abstract

Introduction: Non-vital teeth have certain characteristics that weaken them, lowering the resistance of the tooth. This fragility is closely linked to the loss of dental tissue , which may be the result of trauma, carie or even endodontic therapy. In this context, the endodontic procedure may lead to an increased removal of tooth tissue , not only in the coronary area when executing the acess cavity , but also in the direct canalar access to the apical third , which may remove dentine in the cervical third. The restoration of these type of teeth is highly discussed in literature , and there are several possible approaches , within which Endocrowns and onlays. This study is based on an analysis of Finite Element (FE) 3D model of a first maxillary premolar.

Objectives: The aim of this study is to compare, in an FE model, the stress distribution between two possible approaches to the restoration of endodontically-treated teeth, *Endocrown* or *Onlay* with a resin build- up.

Materials and Methods: The premolar model with two root canals was isolated and was worked according to the type of cavity required, so as to simulate a tooth with a large coronal destruction, a remaining vestibular wall and the canals were filled with guta-percha. The tooth restoration with a fully ceramic *Endocrown* and a ceramic *Onlay* with a resin core was posteriorly simulated. Three power intensities (200 , 500 and 800 *Newtons*) were applied with two different angles (11º and 45º) in relation to the long axis of the tooth. These forces were appied in the occlusal surface of the model with a metal sphere of 4 mm.

Results: This study compared the stress distributions and the maximum stress values in the dental tissue and restorative materials (enamel , dentin , ceramics and composite resin*) and* in the dental tissue only (enamel and dentin). It was possible to observe a higher concentration of stress with a 45º angle, in both models . The *Endocrown* had higher stress values in all tests except when analyzing the values on enamel and dentin with the application of a 11º inclination force.

Conclusions: Despite the limitations of this study, we can conclude that forces with a 45º angle to the long axis of the tooth generate higher stress values in the tooth compared to forces to 11º. It can also be concluded that when these most destructive forces are applied , the restoration through *Onlays* shows better results than the restoration with *Endocrowns*.

Keywords: *Endocrown* ; *Onlay* ; Finite Element ; *Restodontics.*

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Introduction

The restoration of Endodontically Treated teeth (ETT) has been a controversial topic for many years. It is known that vitality loss causes physical and structural changes affecting the dentin properties such as micro-hardness, modulus of elasticity and fracture toughness[(1)].

Many factors affect the endodontic treatment success. During the endodontic procedure, different techniques that may be used during the root preparation, irrigation or during the obturation have long-term functional effects on endodontically treated teeth[(2)]. Usually ETT have inadequate remaining coronal structure as a result of cavity preparation, caries or trauma and present higher risk for biomechanical failure when compared to vital teeth, making the management and decision of the restoration a challenging procedure in the field of restorative dentistry[(3)].

The type of restorative materials used and an appropriate restoration that conserves the reaming tooth structure are the factors that affect the longevity of endodontic treatment. The quality and integrity of the remaining tooth structure should be preserved in all cases to provide a solid and reliable base required for the restoration and structural strength of the restored tooth [(4)].

Fracture strength of a tooth is directly related to the quantity of remaining healthy dental tissue, the loss of the marginal ridges, the increased isthmus width of the preparation and its depth[(5)]. Restorative procedures are the major causes in weakening the tooth since a MOD preparation decreases the tooth stiffness by 63% and a two-surface cavity reduces 43% while the endodontic procedure only reduce 5% by the execution of the access cavity[(6)].

Traditionally, the coronal restoration of ETT was mainly performed with a post and core, as well as with metal or glass fibre-reinforced posts[(7)].

Concerns regarding the procedure of installing a post include some risks as root perforation and removal of sound tissue in the root canal to facilitate the space for the post, thus weakening the tooth-root complex. In recent years, the overall benefit and the retention given by posts is a questionable subject[(8)].

One study[(9)] analysing the difference between the insertion of posts when restoring endodontically treated molars has shown that there is no difference between inserting a post or not .

Adhesive methods and ceramic materials recent improvements arouse clear advantage to adhesive restorations since macro-retentive designs are no longer a pre-requisite for the choice of the restoration if the preparation leaves sufficient tooth structure/ surfaces for bonding[(10)].

Indirect restorations can be classified mainly as *Inlays*, that are fully intracoronal; *Onlays*, which overlie one or more cusps; *Overlays*, which overlie all cusps or, more recently, *Endocrowns*, when there is a great destruction of the coronary portion of the teeth. These type of restorations enable the recovery of aesthetics and fracture resistance of posterior teeth, in addition to being more conservative alternatives when compared to conventional crowns, that can be made of metal, ceramic or composite resin[(11)].

However, ceramics have the best aesthetic and mechanical resistance results as they can mimic the translucency and structure of natrural teeth. In addition to a pleasing appearance, these materials are biocompatible and the coefficient of thermal expansion is similar to enamel[(12)].

Pissis[(13)] was the developer of the *Endocrown* technique, describing it as the ‘mono-block porcelain technique’. The nomenclature *Endocrown* was firstly described by Bindl and Mormann[(14)] in 1999 as adhesive endodontic crowns characterized as total porcelain crowns fixed to depulped posterior teeth. These crowns would be anchored to the internal portion of the pulp chamber and on cavity margins, thus obtaining macro-mechanical retention provided by the pulp walls, and micro-retention would be obtained with the use of adhesive cementation. These type of restorations are indicated when there is excessive loss of coronal structure or limited interproximal space[(15)].

Compared to other indirect restoration approaches that require root canal therapy, the *Endocrown* alternative is technically easy to do, a cost-effective procedure that requires less chairside time, helping the acceptance by the patient. In addition, supragengival margins facilitate the oral hygiene and clinical inspection[(8)].

Different materials can be used to produce an *Endocrown*, such as feldspathic and ceramic reinforced with lithium dissilicate, hybrid resin composites and the newest CAD/CAM ceramic and resin composite blocks. These blocks can be used instead of classical lab-made restorations in order to avoid defects inherent to a free-hand laboratory technique, such as errors in the impressions and deformations of the ceramic[(16)].

This is a Finite Element Analysis (FEA) study, which consists in a computer model of a material or design that is stressed and analysed for specific results[(17)].

The aim of the study is to analyse and compare those results between two types of restorations of endodontically treated first maxillary premolars: *Endocrown* and *Onlays* with a resin build-up. The null hypothesis is that there are no differences between the two groups.

Materials and Methods

Finite Element model generation

The solid model consists of a maxillary first premolar, without the periodontal ligament because it is a very small element with some peculiar characteristics such as its hyper-elastic proprieties. These are very difficult to represent in the model and would make a non-linear study which complexity would add a bias to this purely comparative study between two models. The surrounding cortical and trabecular bone was represented and used as anchorage. The initial maxillary model (Fig. 1) was kindly donated by the Brazilian Engineer Estevam Barbosa De Las Casas (IEAT Director, School of Engineering, Federal University of Minas Gerais (UFMG), Belo Horizonte MG, Brasil) and was organized and processed by ISEC students André Oliveira, Rui Catarrinho and Júlio Regado from the Mechanical Engineer Master coordinated by Professor Doutor Luis Roseiro. The software used to design and work on the different models and preparations was SolidWorks (SolidWorks 2015, Waltham, Massachusetts, USA).

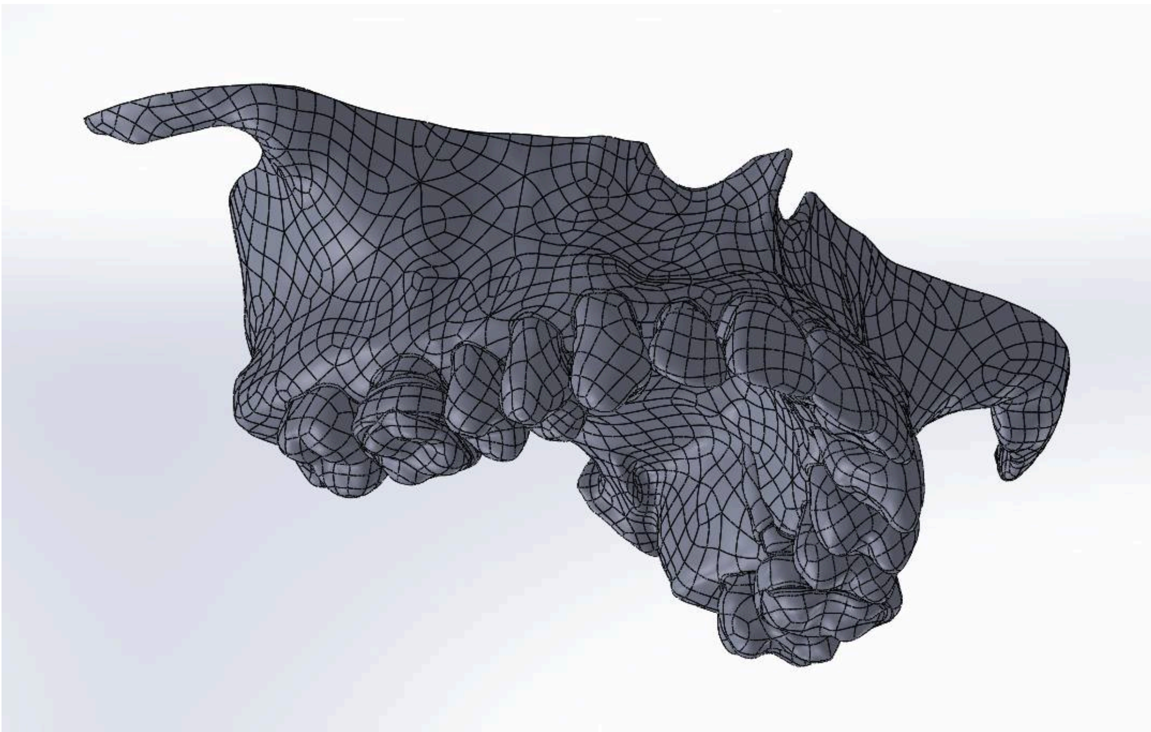

Fig.1: Complete model from where the first premolar was isolated.

The first premolar (Fig. 2) was prepared with two roots and the canals had 0.3 mm diameter at the apex and 1,3 mm diameter in the most coronal point, with a conical shape and it was filled with guta-percha. The tooth was sectioned 1mm above the cement-enamel junction (CEJ) and the vestibular wall remained 2,3 mm thick with 3 degrees of divergent tapper. The central cavity to the pulp chamber was defined 1.6 mm from the margins, in an elliptical cavity 1,5 mm deep.

The tooth has a crown 7 mm high and the buccal-lingual and mesio-distal distance is 10,3 mm and 6,1 mm, respectively.

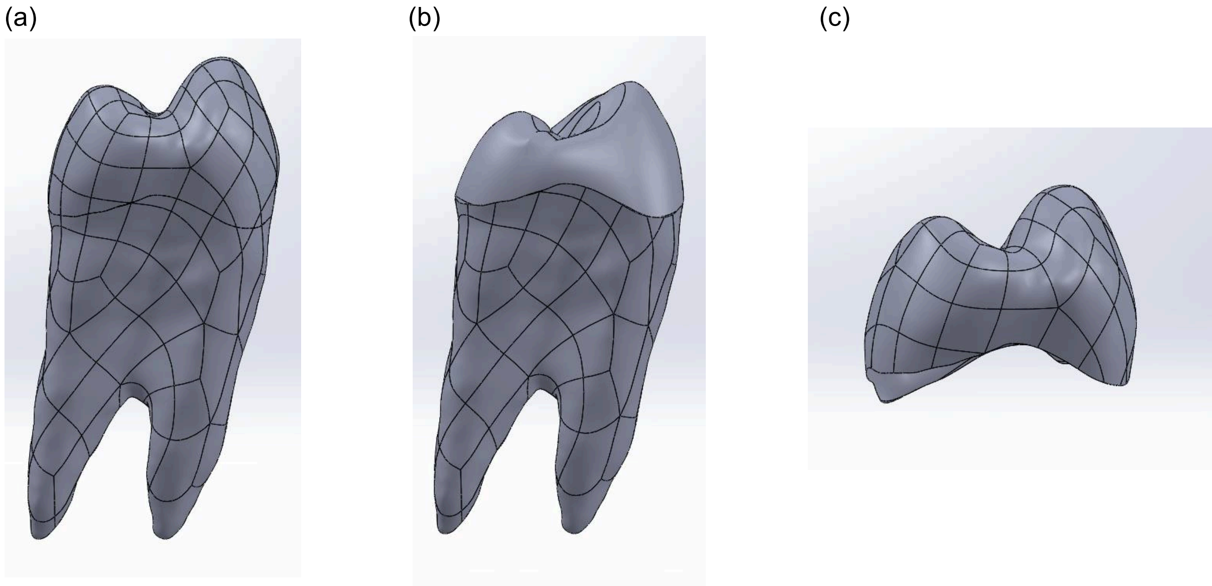

Figure 2: Isolated tooth (a), the tooth without the enamel portion (b) and the enamel fraction (c).

The vestibular cusp was covered, because the contemporary literature reports better results and higher success rates when the restoration covers both cusps in endodontically treated premolars.

The adhesive and the cement were not taken into account because they are extremely small elements that couldn't be recreated in this type of model.

Linear elastic, homogeneous and isotropic material properties of the tooth tissues, bone and restorative materials were assigned according to the volume definition from previous literature (Table I).

Table I: Material properties (Young's modulus and Poisson coefficient)

	Young's modulus	Poisson coefficient	References
Enamel	41	0,31	(2)
Dentin	18,6	0,31	(2)
IPS Empress Direct	15,5	0,24	(18)
IPS E-max Press	95	0,23	(19)
Guta-percha	0,14	0,45	(2)
Cortical Bone	13,7	0,30	(2)
Trabecular Bone	1,37	0,30	(2)

A convergence test was made resulting in a Solid Mesh model (Fig. 3) with a curvature based mesh type with 4 Jacobian points. The size of the maximum element is 1,5 mm and the minimum element is 0,3 mm with high quality and 3 degrees of freedom, finally resulting in a model with 76,997 elements and 118,475 nodes. This model has a 96,1% element percentage, which makes this a reliable study (Table II).

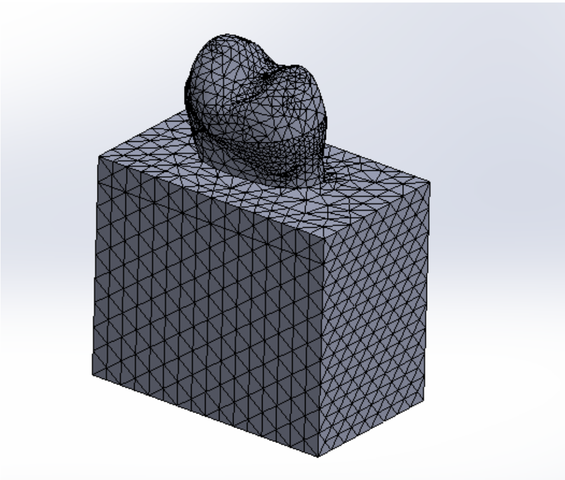

Fig.3: Mesh of the experimental model.

Study name	
Mesh type	Solid Mesh
Mesher Used	Curvature based mesh
Jacobian points	4 points
Mesh Control	Defined
Max Element Size	1.5 mm
Min Element Size	0.3 mm
Mesh quality	High
Total nodes	118475
Total elements	76997
Maximum Aspect Ratio	555.03
Percentage of elements with Aspect Ratio < 3	96.1
Percentage of elements with Aspect Ratio > 10	0.29
% of distorted elements (Jacobian)	0

Table II: Characteristics of the mesh model.

In this study 3 models were created:

<u>Model 1</u>: Sound tooth.

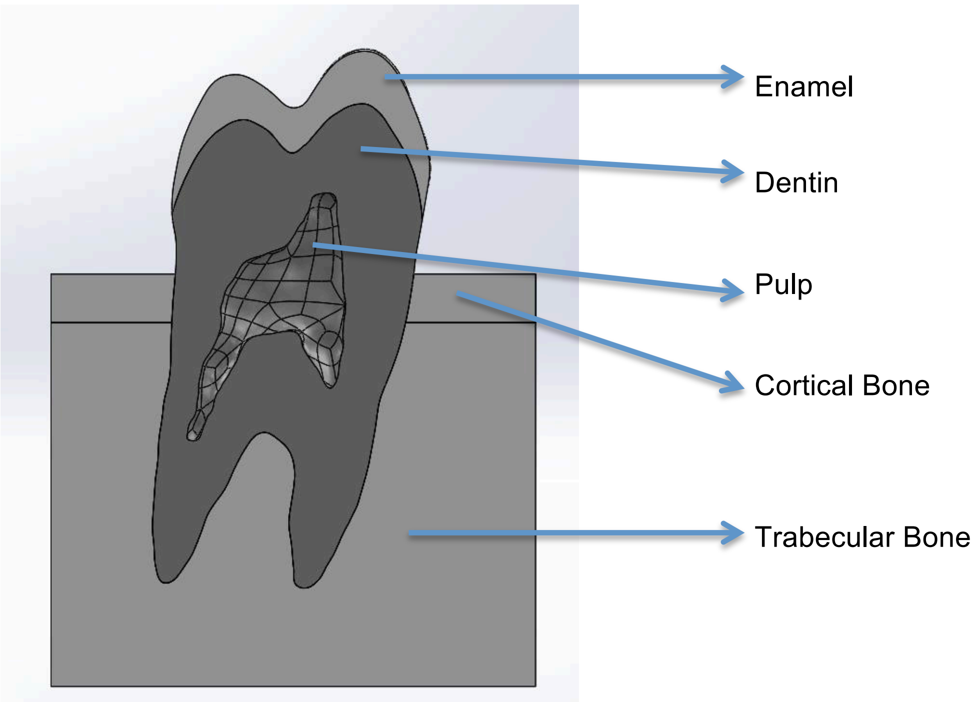

Fig.4: Scheme of model 1.

Model 2: Endodontically treated maxillary first premolar restored with a ceramic (Fig.5) *Endocrown* (IPS e.max Press, Ivoclar Vivadent, Liechtenstein).

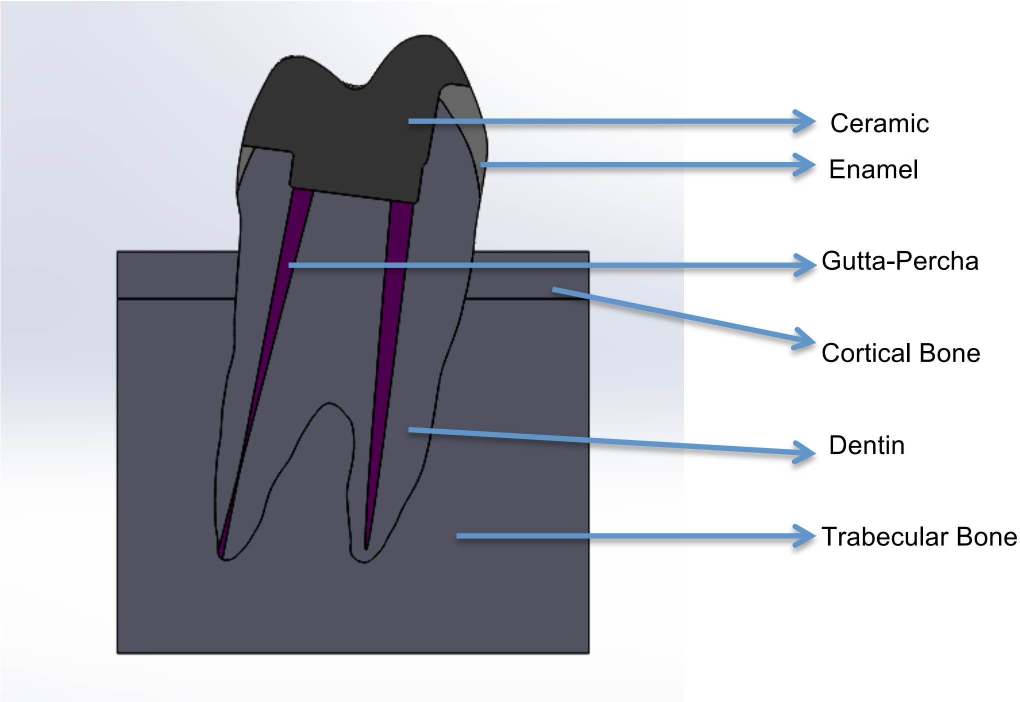

Fig.5: Scheme of Model 2.

Model 3: Endodontically treated maxillary first premolar restored with a ceramic (Fig. 6) *Onlay* (IPS e.max Press, Ivoclar Vivadent, Liechtenstein) with a resin build-up (IPS Empress Direct, Ivoclar Vivadent, Liechtenstein).

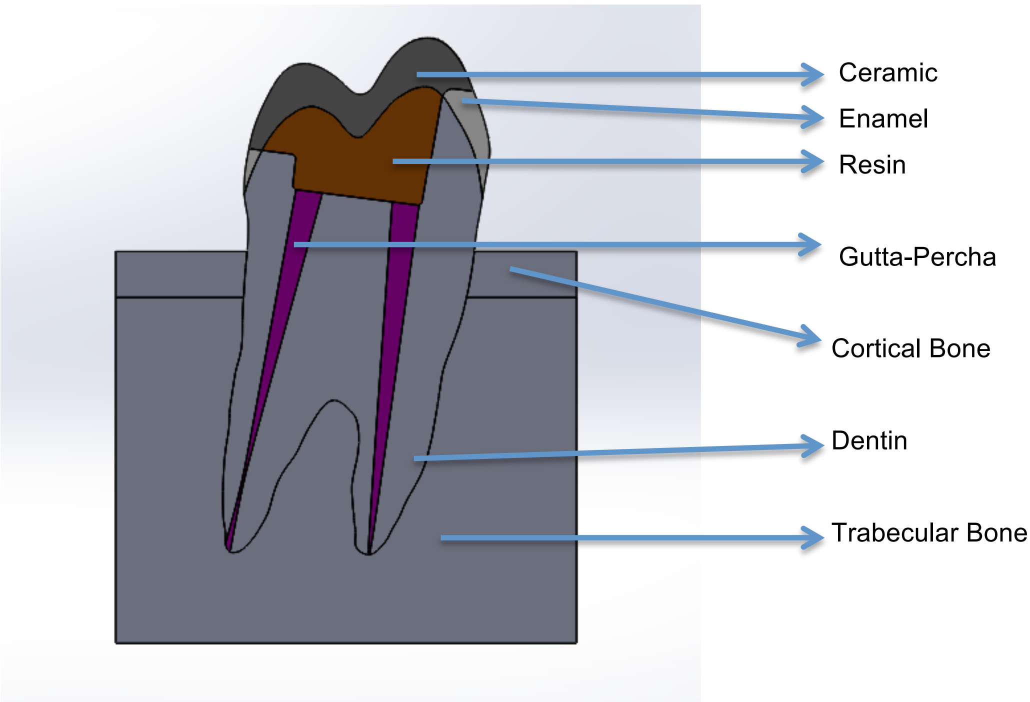

Fig.6: Scheme of Model 3.

Finite Element Analyses

The load was applied on the tooth with buccal and lingual cusp contact for simulating the axial load with a 4 mm sphere diameter with a 11º (Fig.7) and 45º (Fig. 8) angle to the long axis of the tooth. A 200 N force was simulated, and stresses of other loads were then applied to simulate approximately the natural biting force (500 N) and a force higher to this natural force (800 N).

The analysis of the results was made with the Von Mises (VM) stress distribution and with the maximum stress values recorded on the model.

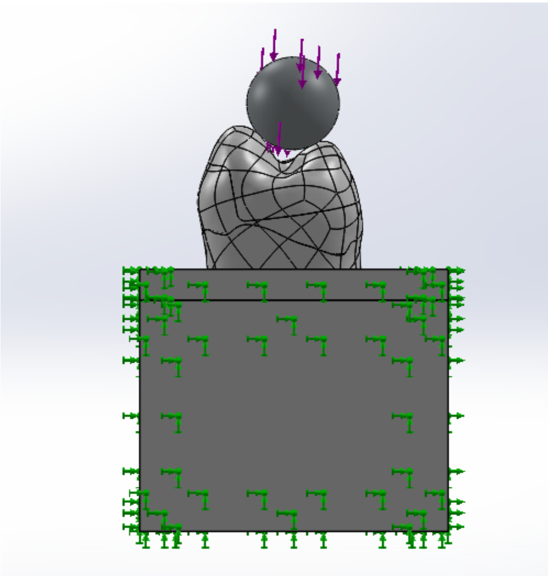

Fig. 7: Force with 11º angle to the long axis of the tooth.

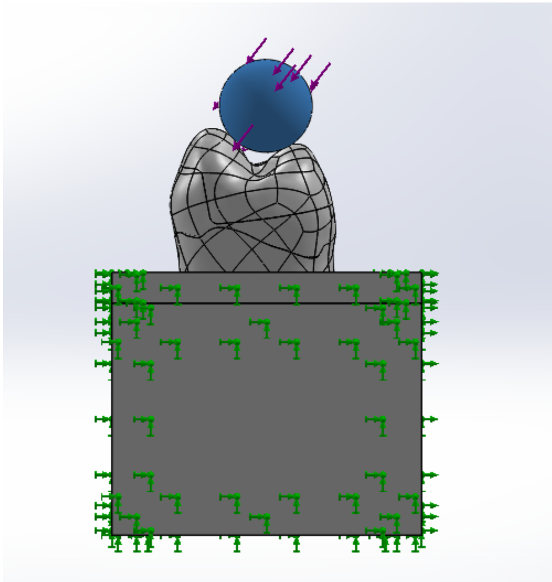

Fig. 8: Force with 45º angle to the long axis of tooth.

Results

For better organization of the results two different groups were made, analysing the VM stress distribution. In the first group: stress was analysed in the tooth structure only (enamel and dentin), and in the second group: stress was analysed in the tooth structure with the restorative materials. Within both groups the analysis were divided between the *Endocrown* and the *Onlay* with resin core restorations. Subsequently the maximum stress values were analysed and organised in 4 tables.

Due to the limitations of the software where the model was designed, there are some hotspots with higher concentrations of stress values that should not be taken into account due to mesh failures, such as the enamel-dentin junction or the area on the root where the simulated bone is anchored.

The following pages demonstrate the different stress distribution between the two types of restorations, caused by the different forces and angles applied to the tooth.

Stress distribution in enamel and dentin

200 N at 11º:

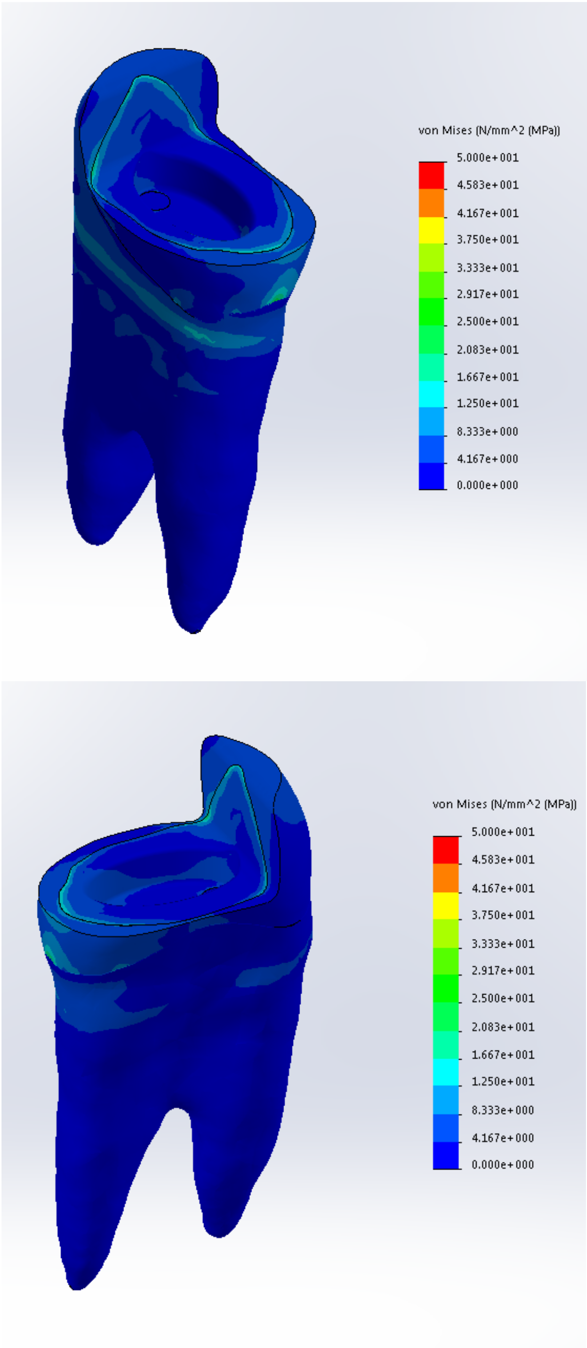

Fig.9: *Onlay* 200 N 11º.

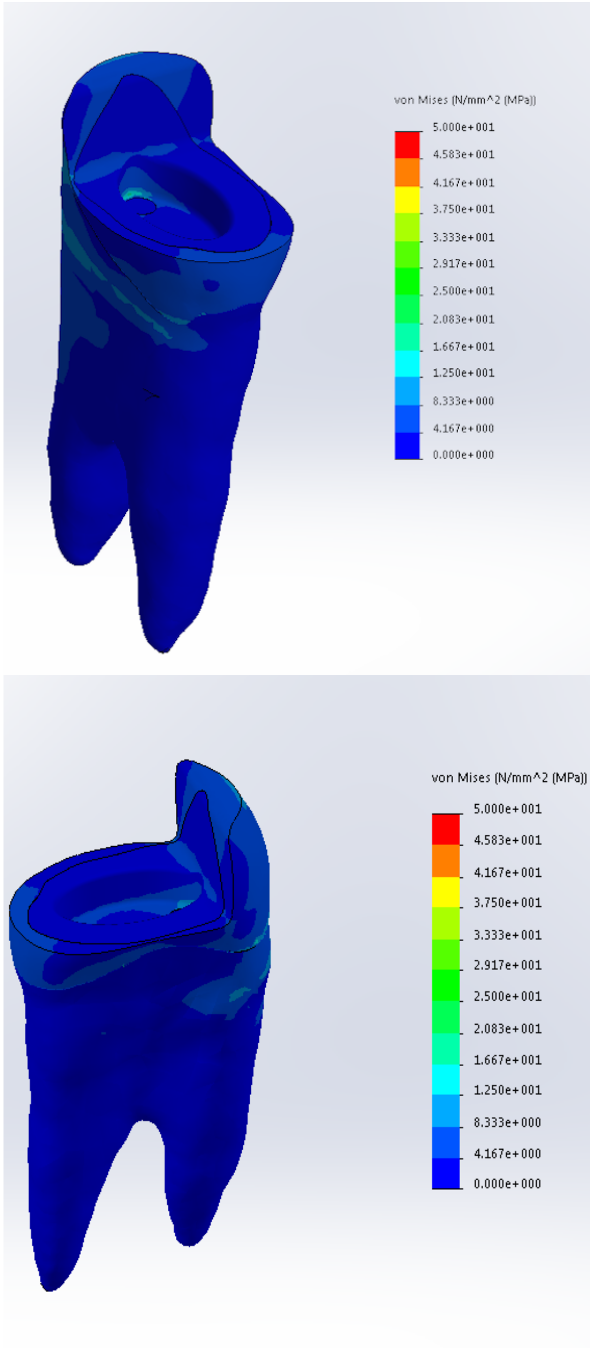

Fig.10: *Endocrown* 200 N 11º.

200 N at 45º:

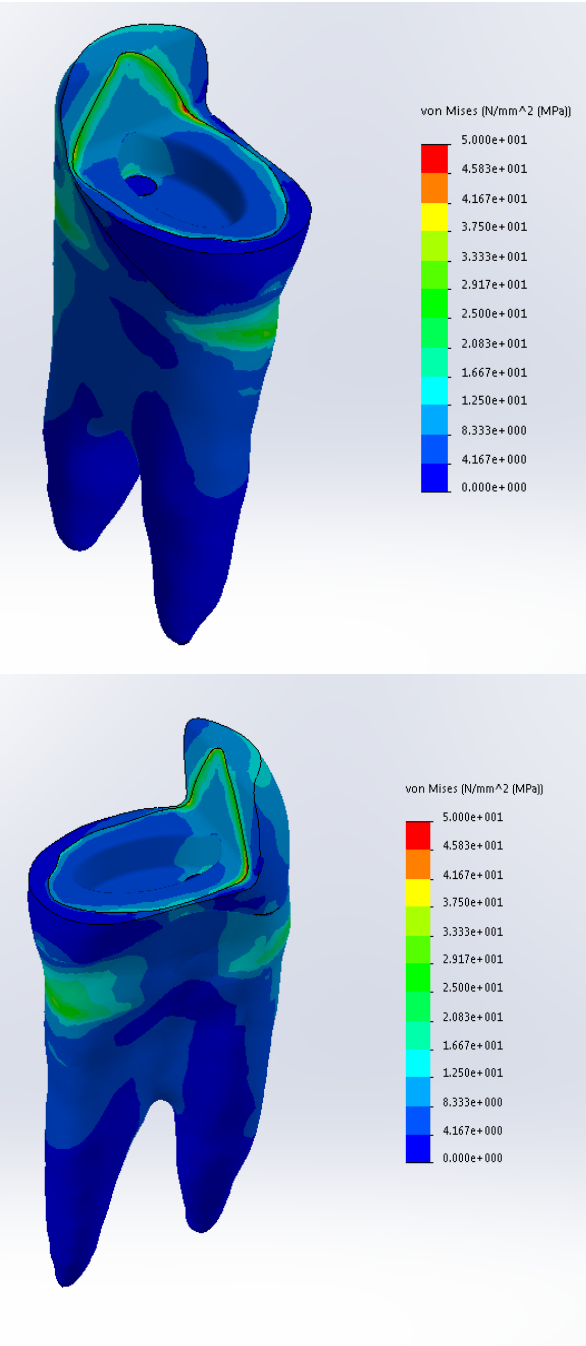

Fig.11: *Onlay* 200N 45º.

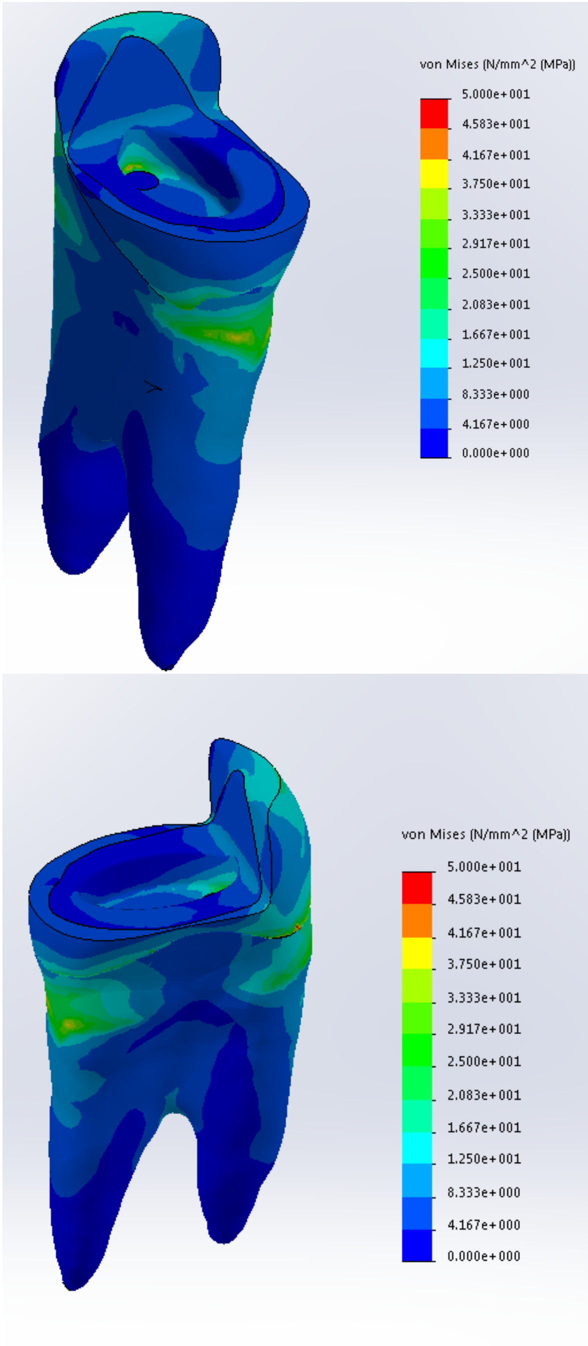

Fig.12: *Endocrown* 200N 45º.

500 N at 11º:

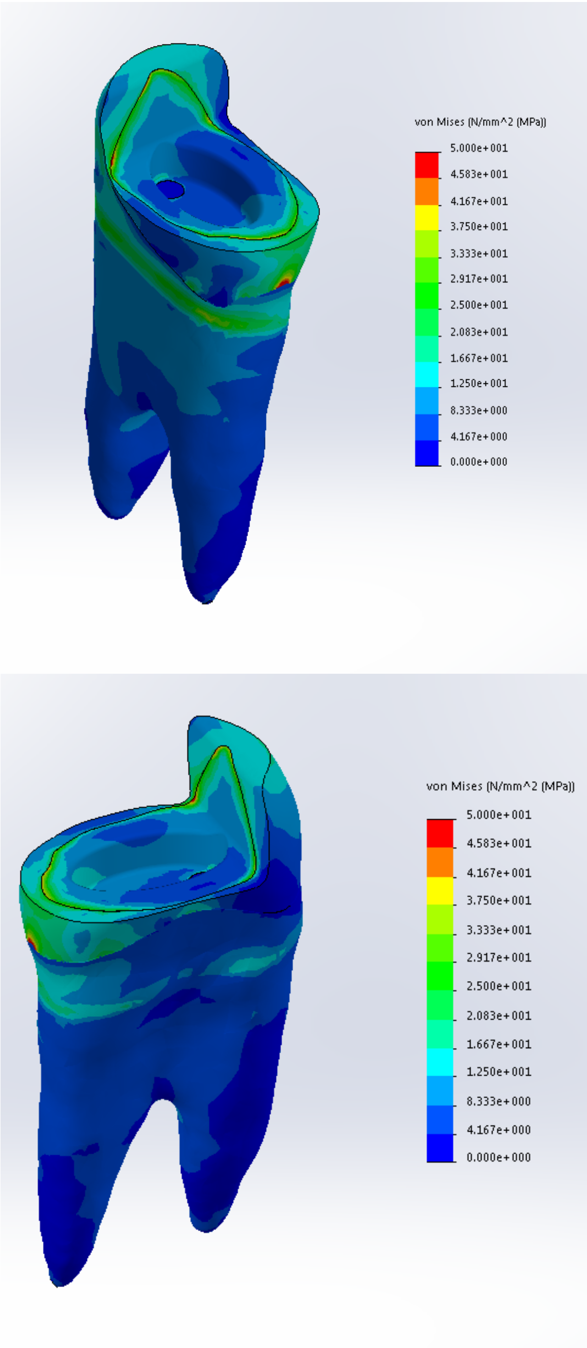

Fig.13: *Onlay* 500 N 11º.

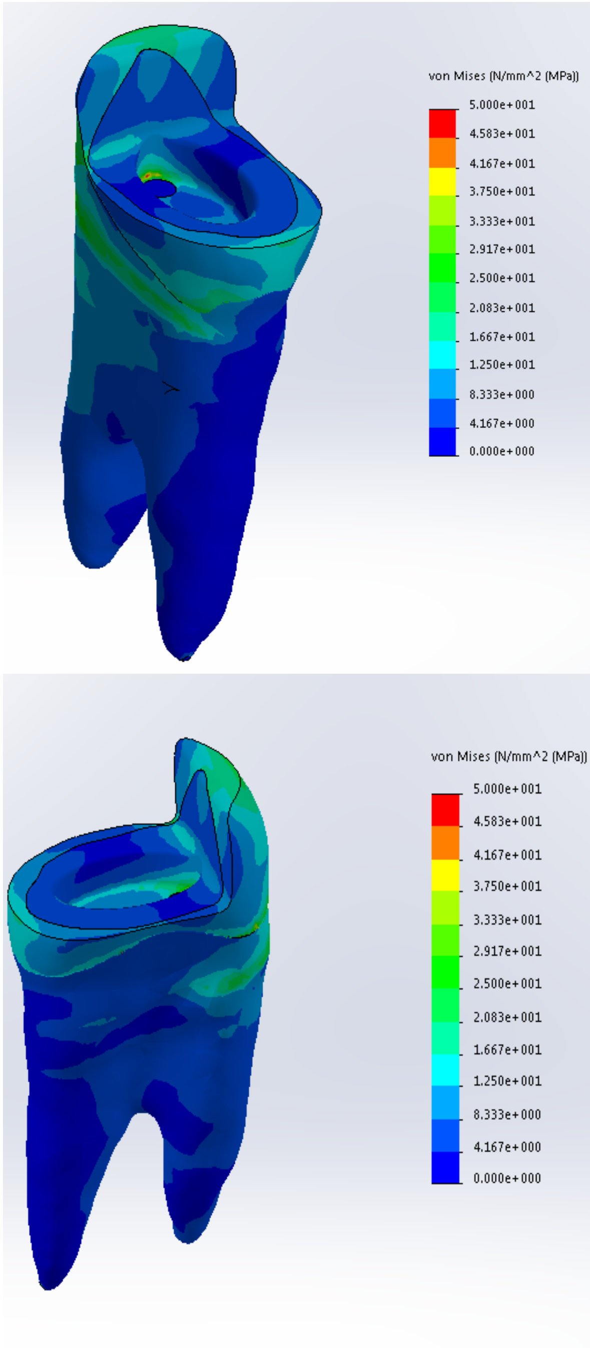

Fig.14: *Endocrown* 500 N 11º.

500 N at 45º:

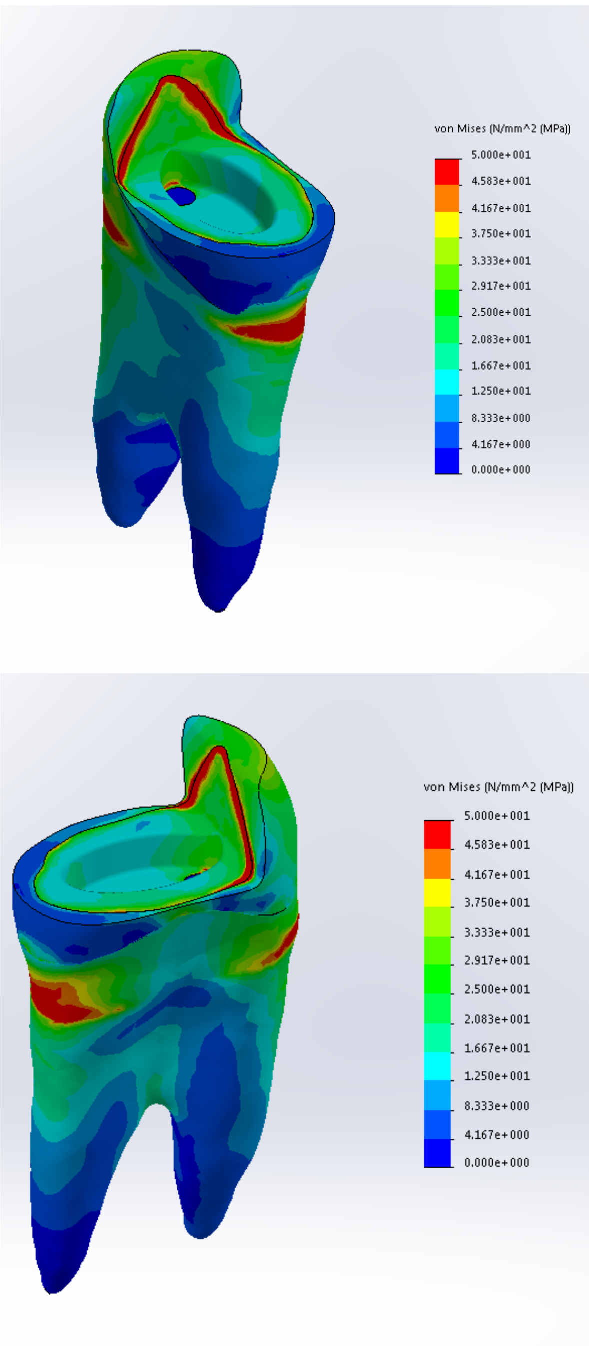

Fig.15: *Onlay* 500 N 45º.

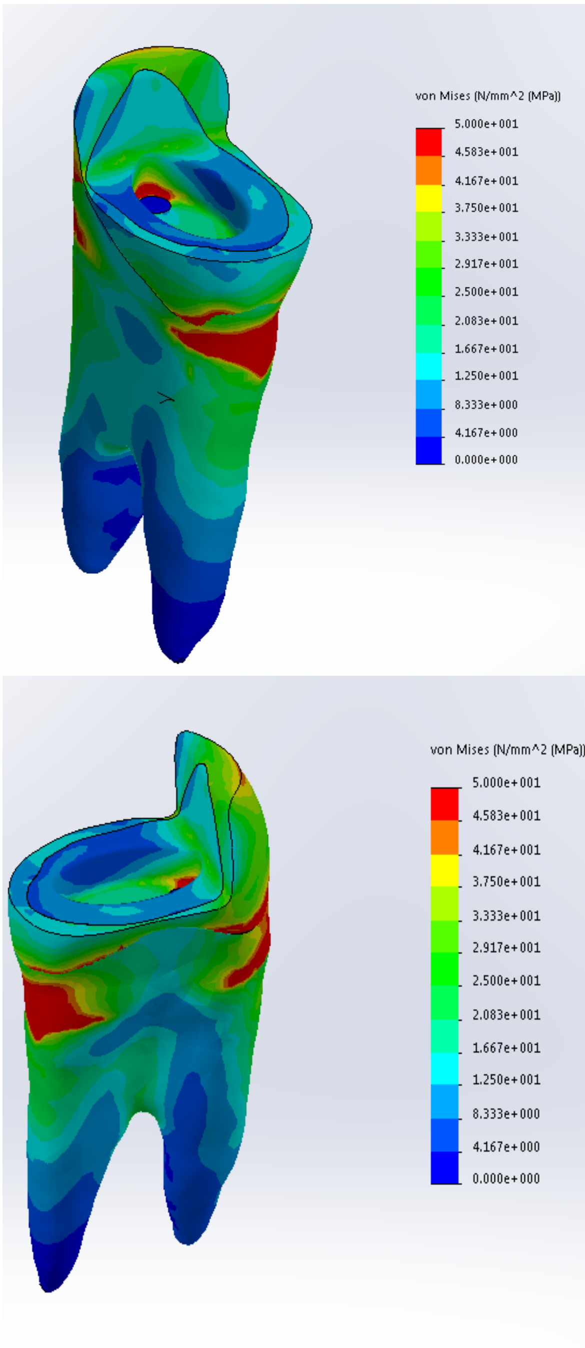

Fig.16: *Endocrown* 500 N 45º.

800 N at 11º:

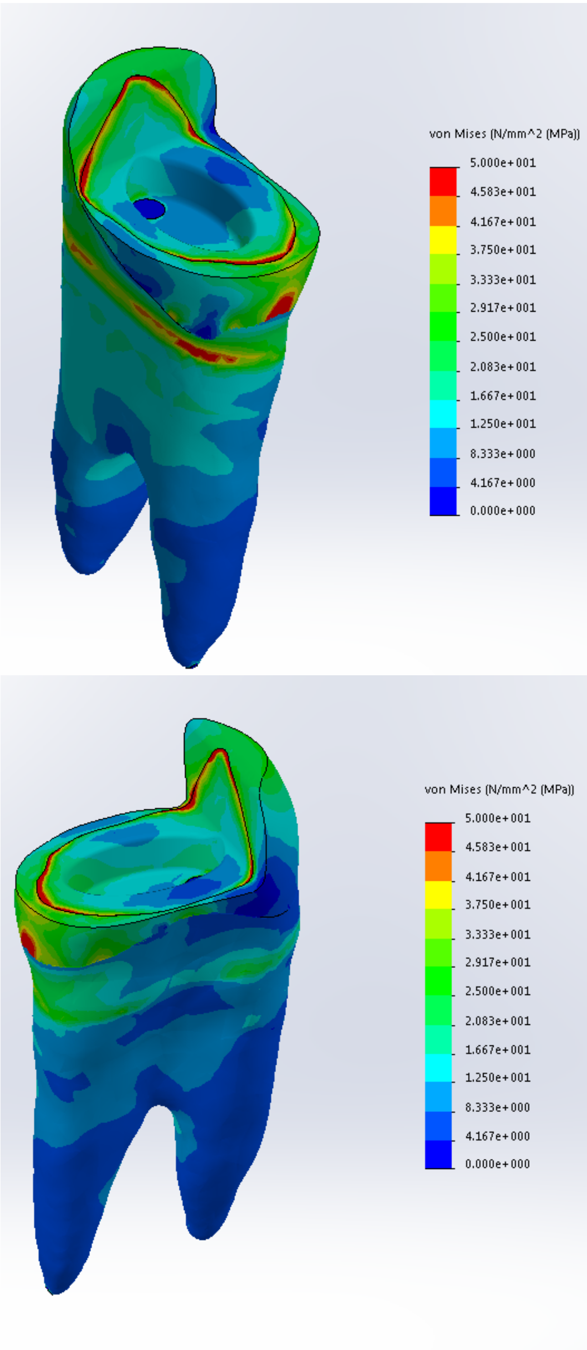

Fig.17: *Onlay* 800 N 11º.

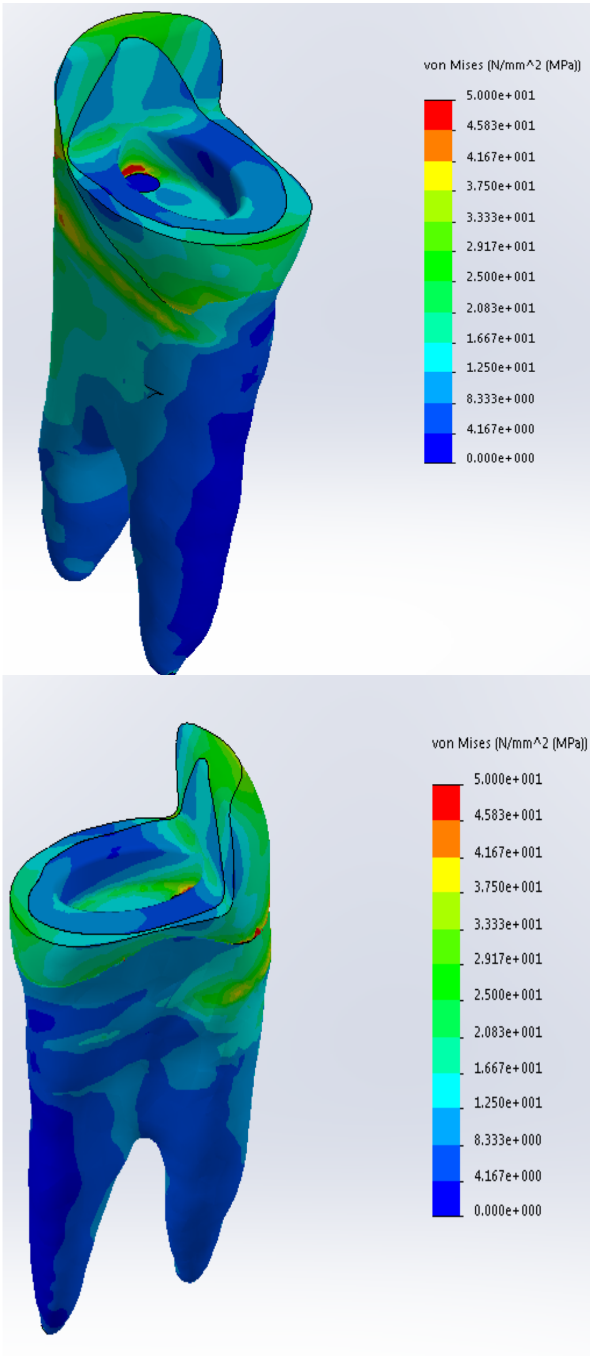

Fig.18: *Endocrown* 800 N 11º.

800 N at 45º:

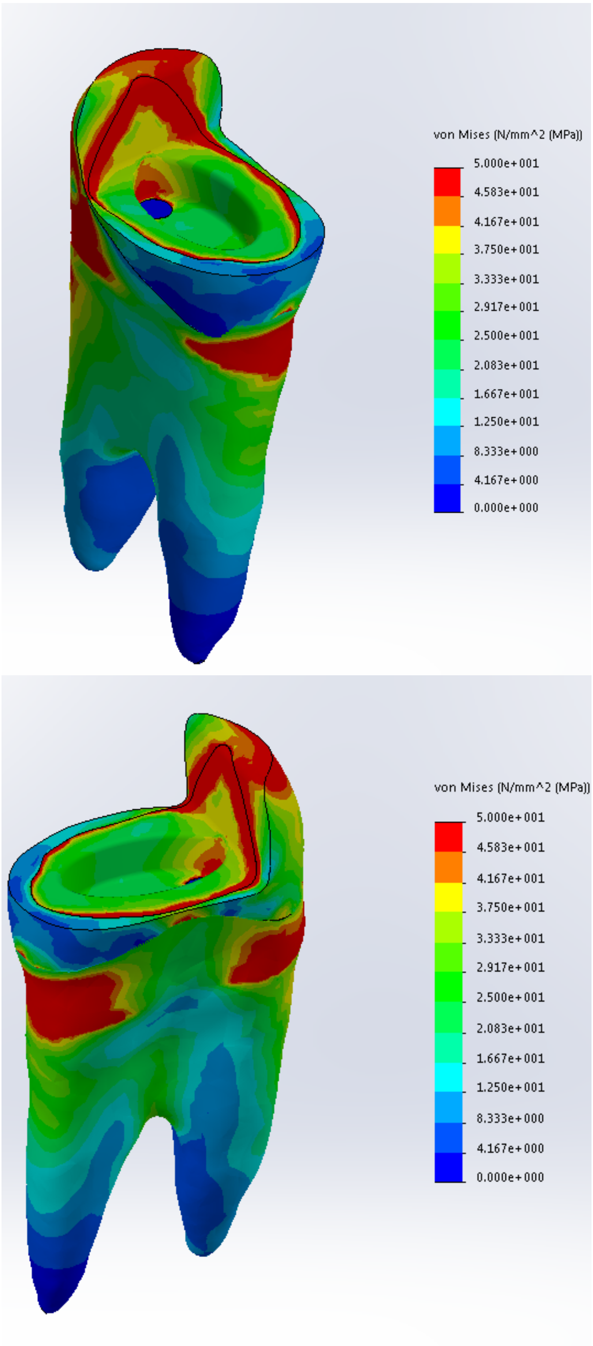

Fig.19: *Onlay* 800 N 45º.

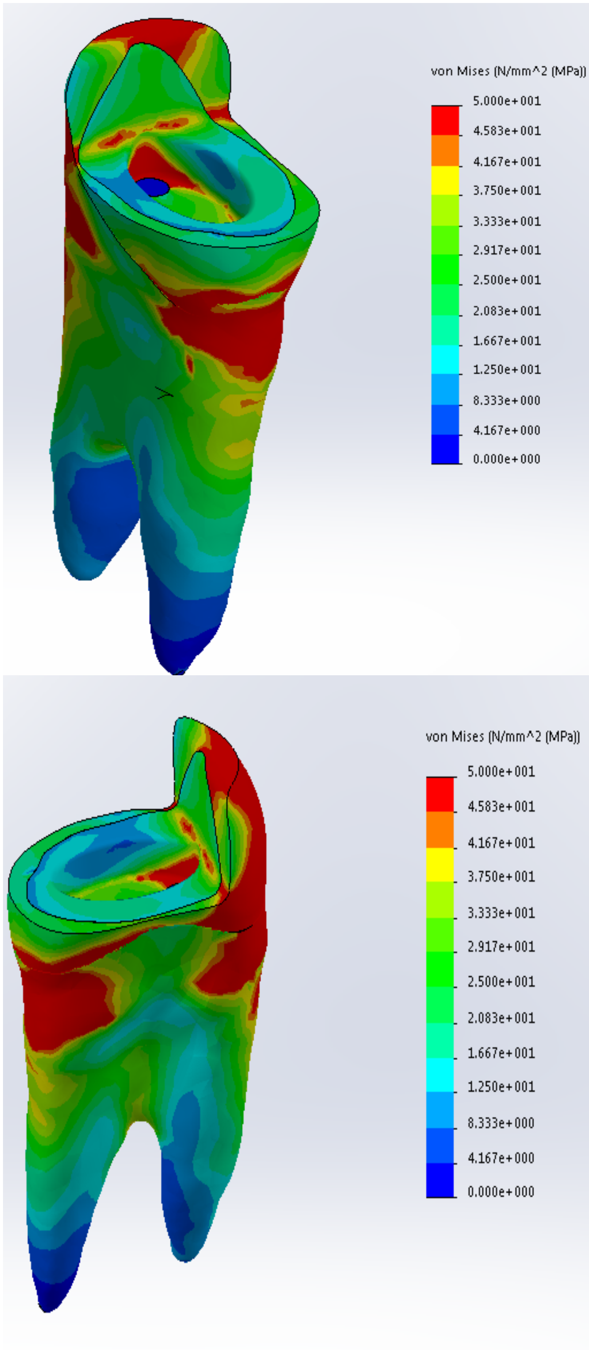

Fig.20: *Endocrown* 800 N 45º.

Stress distribution on the tooth and restorative material

200 N at 11º:

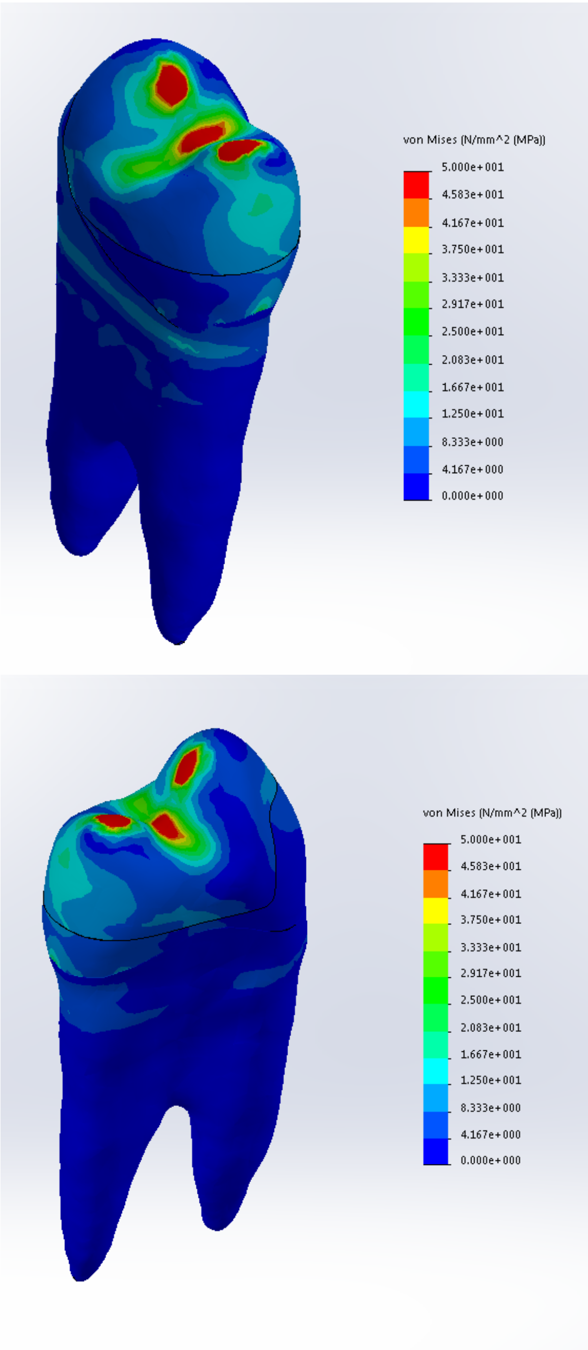

Fig.21: *Onlay* 200 N 11º.

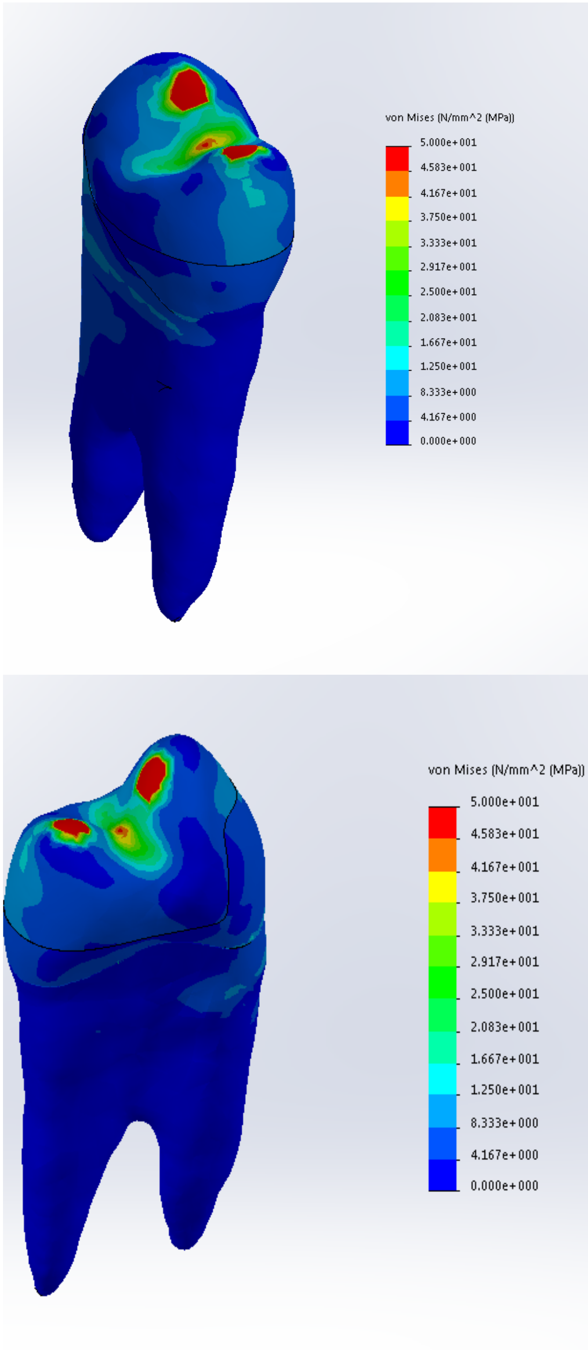

Fig.22: *Endocrown* 200 N 11º.

200 N at 45º:

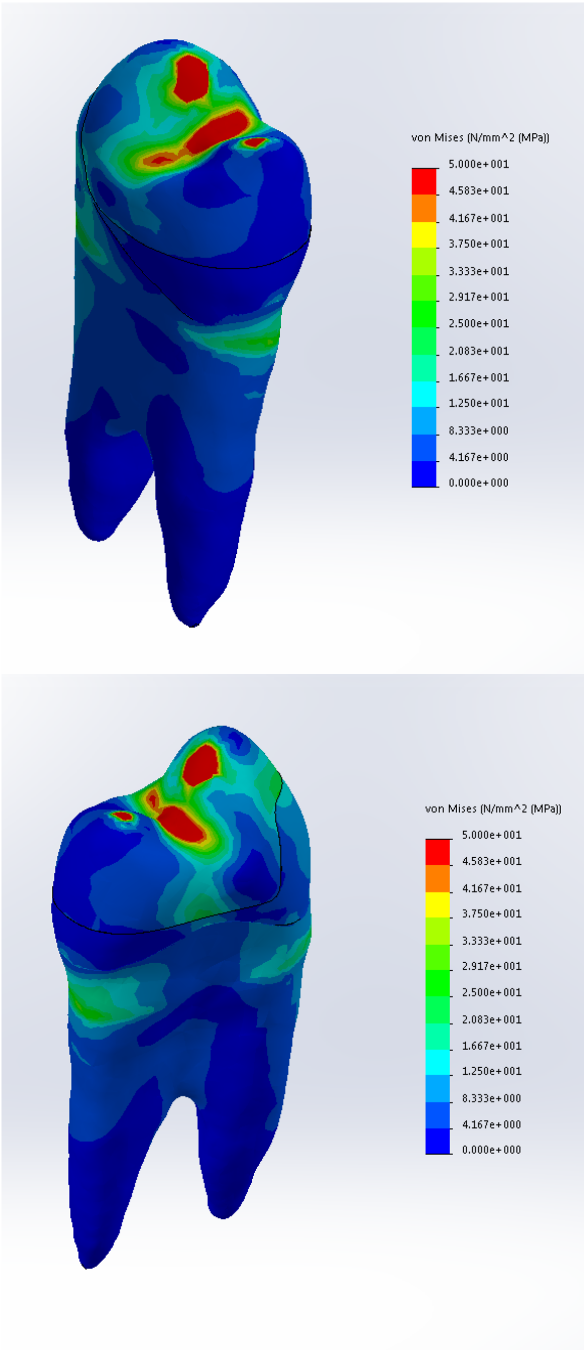

Fig.23: *Onlay* 200 N 45º.

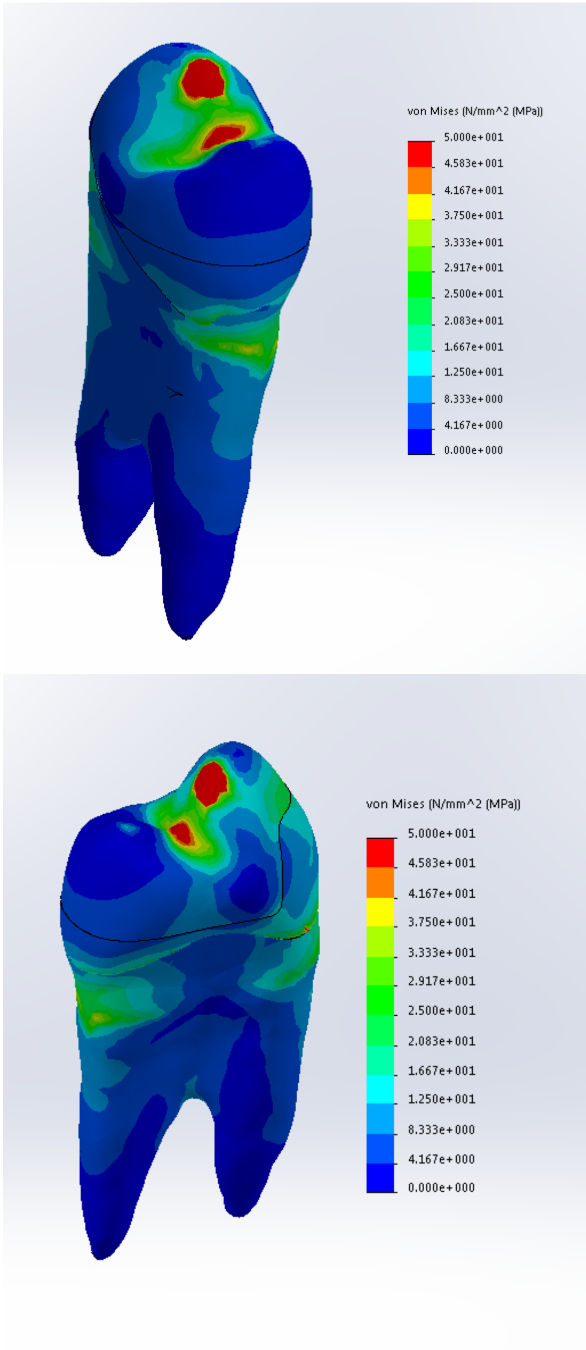

Fig.24: *Endocrown* 200 N 45º.

500 N at 11º:

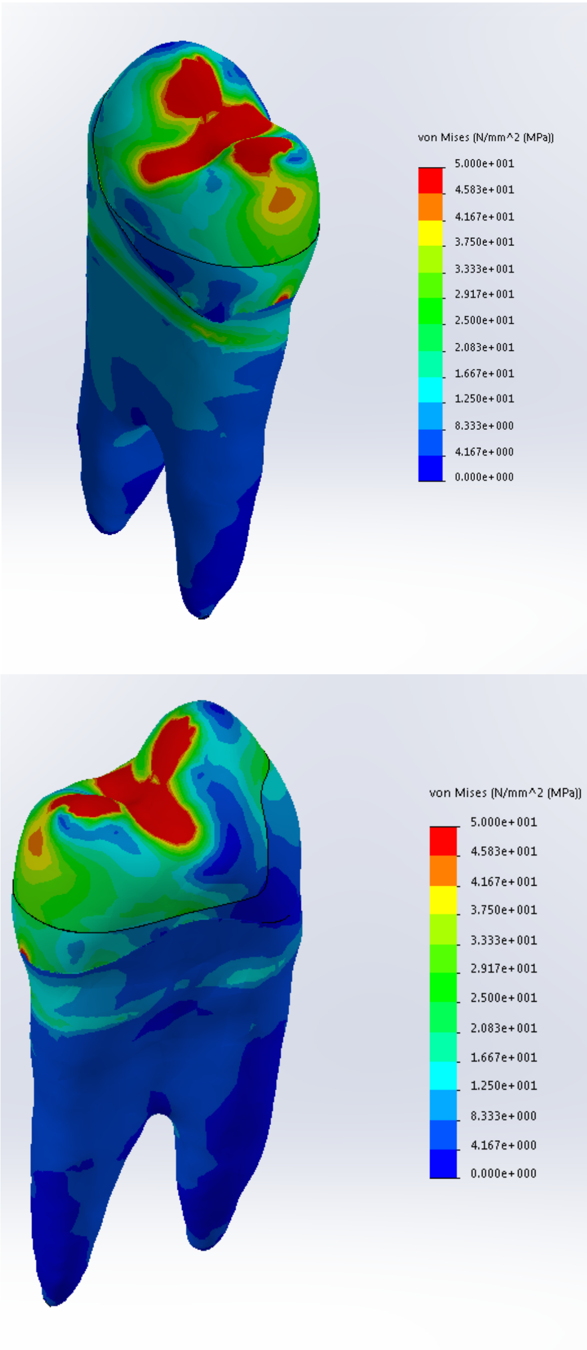

Fig.25: *Onlay* 500 N 11º.

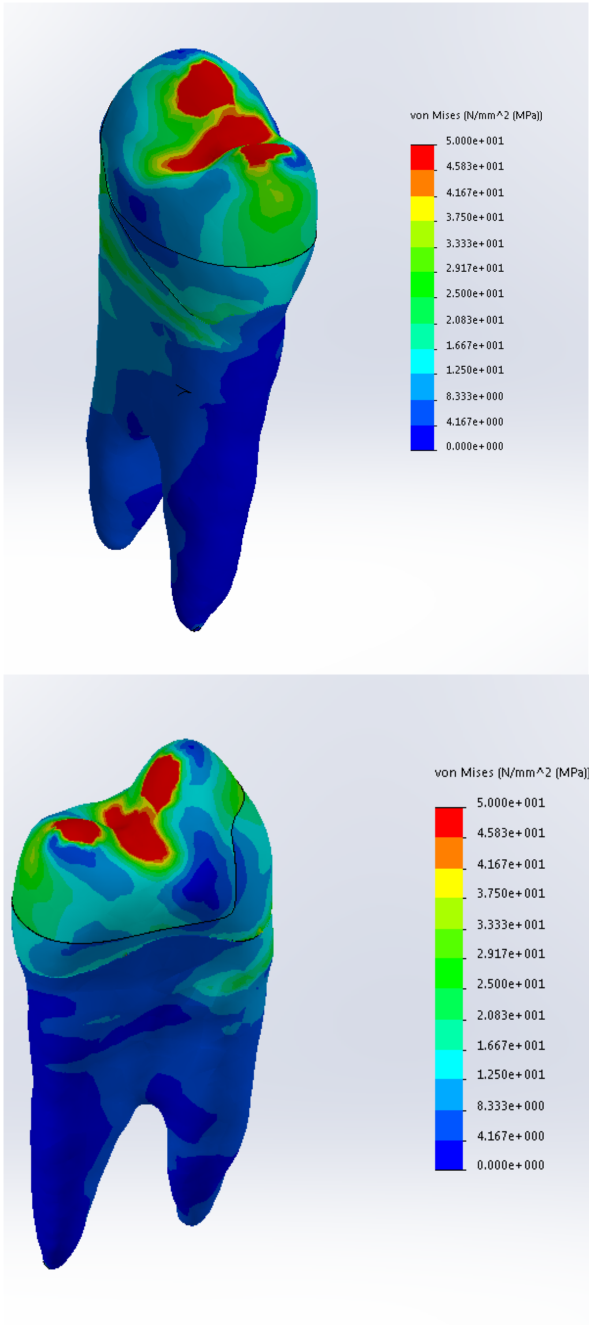

Fig.26: *Endocrown* 500 N 11º.

500 N at 45º:

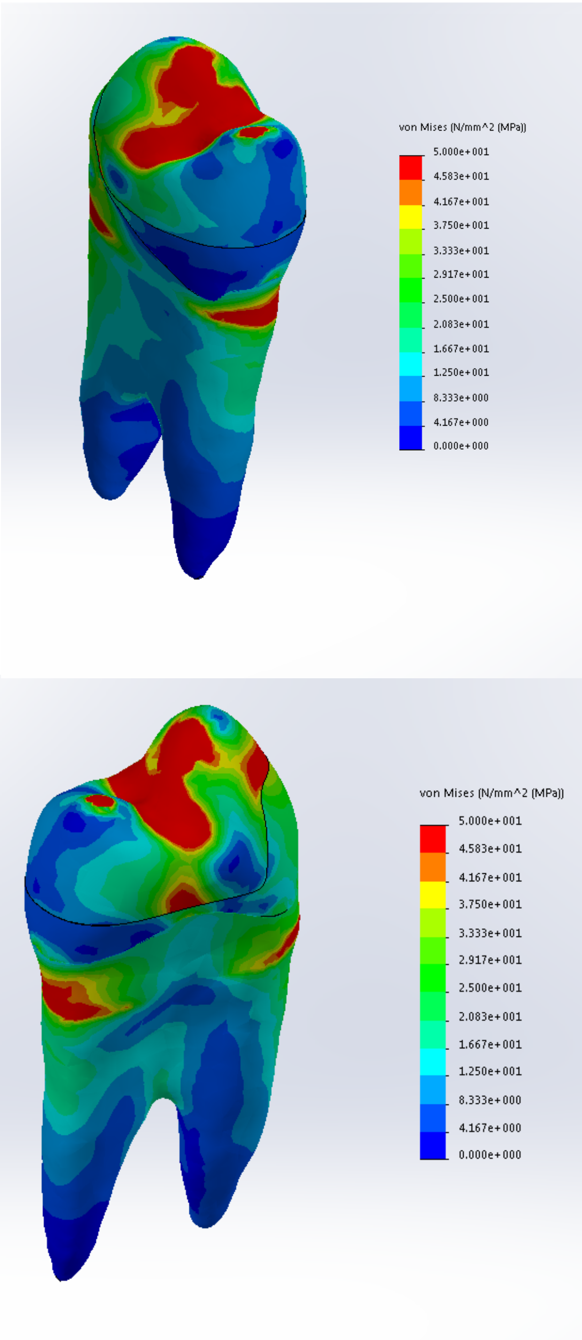

Fig.27*: Onlay* 500 N 45º.

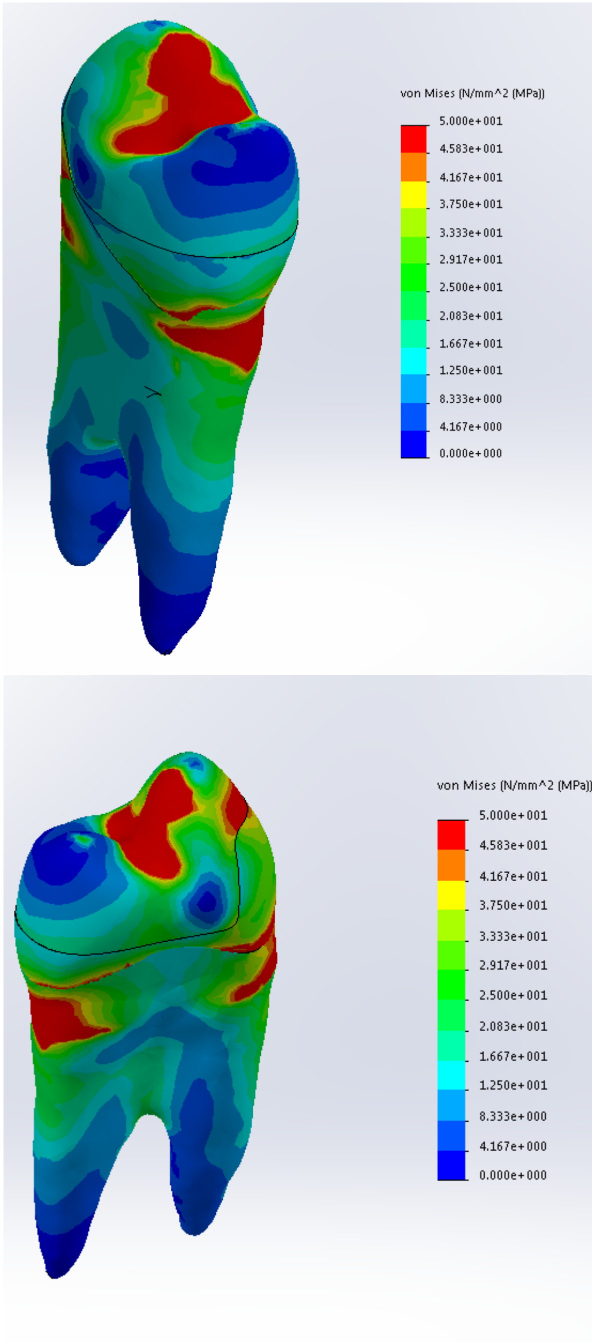

Fig.28: *Endocrown* 500 N 45º.

800 N at 11º:

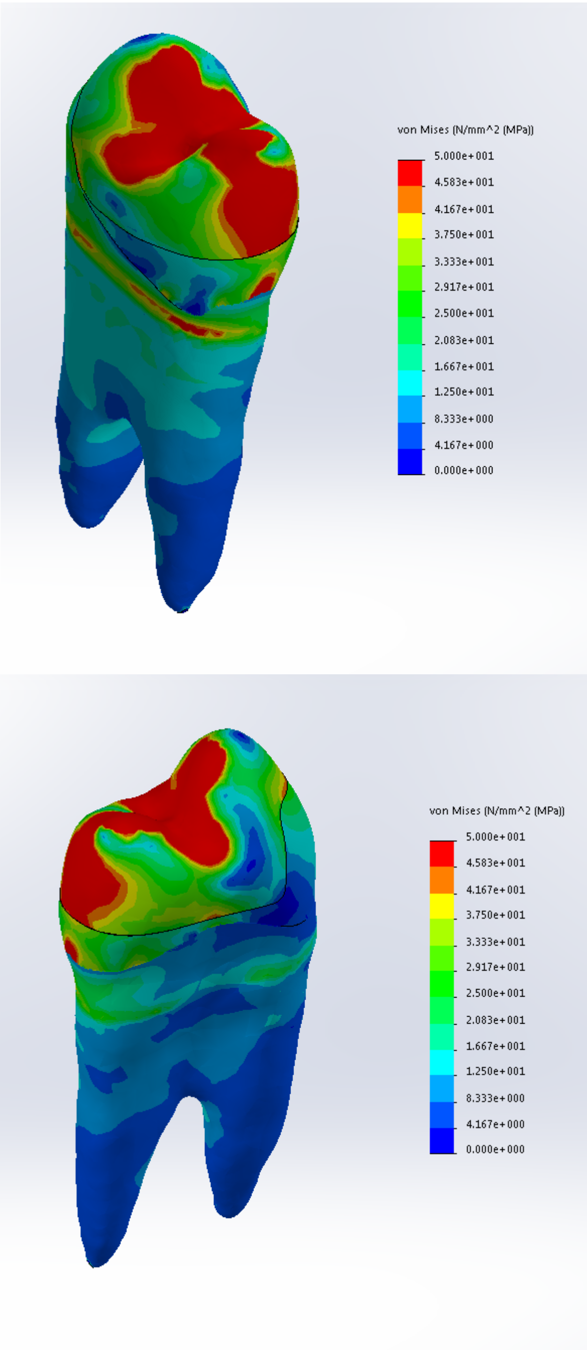

Fig.29: *Onlay* 800 N 11º.

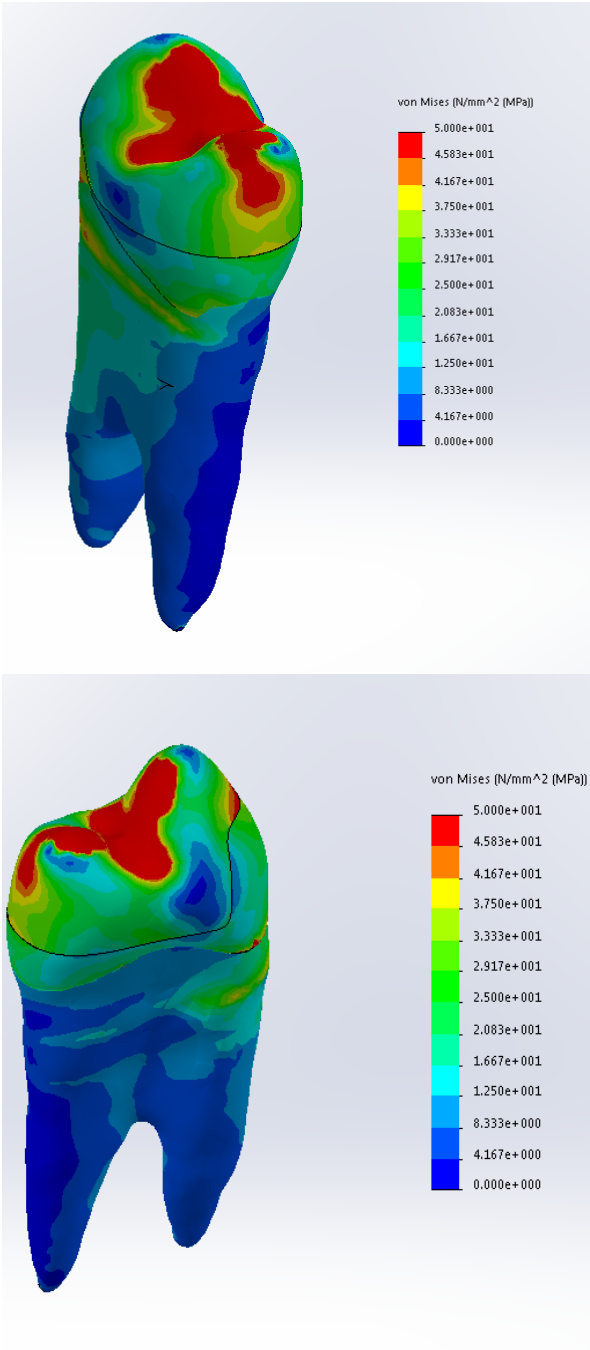

Fig.30: *Endocrown* 800 N 11º.

800 N at 45º:

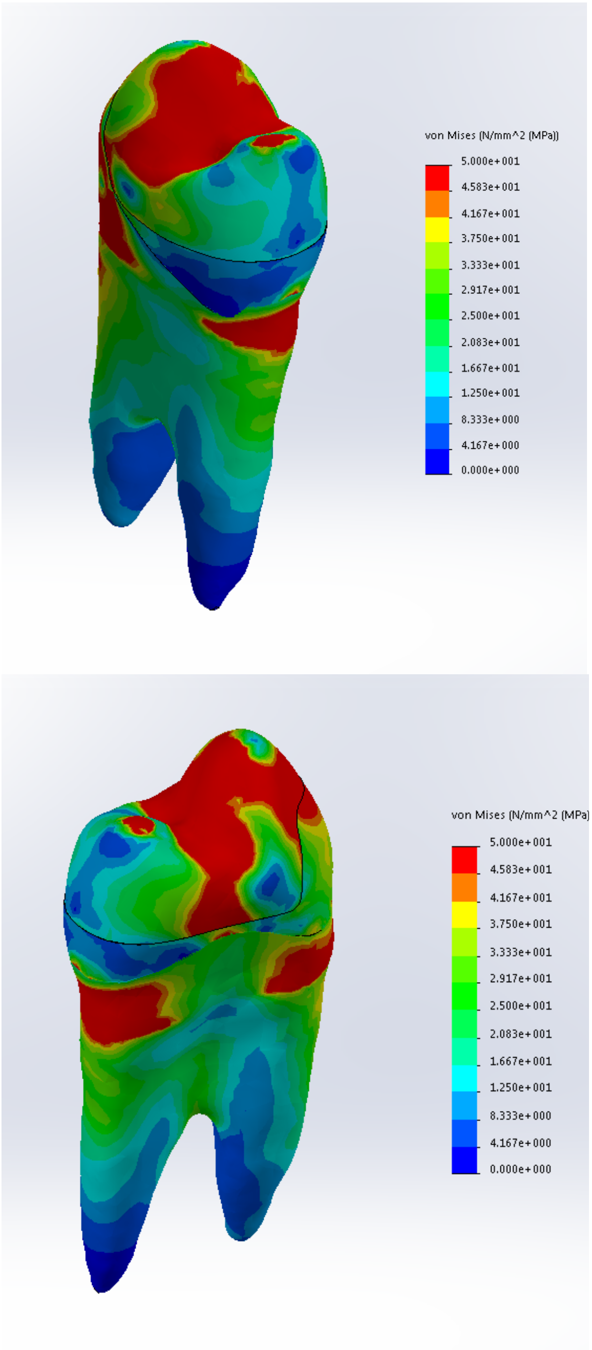

Fig.31: *Onlay* 800 N 45º.

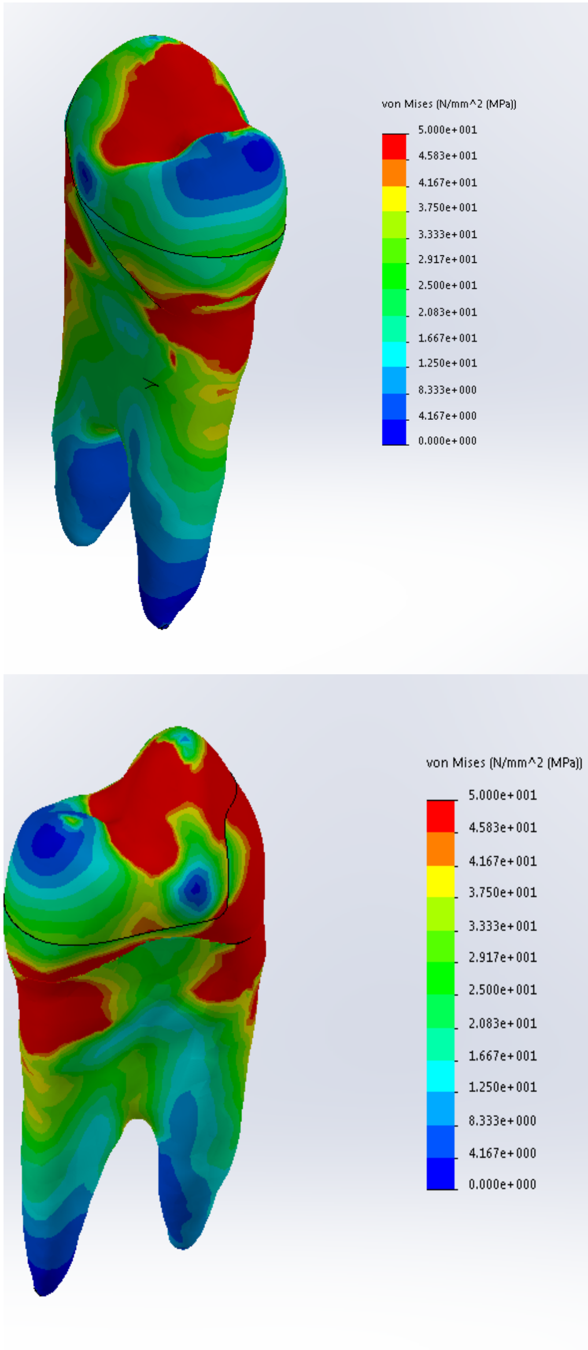

Fig.32: *Endocrown* 800 N 45º.

Table II: Relation between maximum stress (MPa) in *Onlay* and *Endocrown* restorations with a 11º force.

	Onlay	*Endocrown*
200 N	175,8	213,1
500 N	360,2	498,8
800 N	569,5	782,6

Table III: Relation between maximum stress (MPa) in *Onlay* and *Endocrown* restorations with a 45º force.

	Onlay	*Endocrown*
200 N	279,6	330,0
500 N	538,2	845,0
800 N	776,4	1336,0

Table IV: Relation between maximum stress (MPa) in *Onlay* and *Endocrown* restorations with a 11º force on enamel and dentin.

	Onlay	*Endocrown*
200 N	24,1	17,1
500 N	60,9	42,6
800 N	98,0	68,1

Table V: Relation between maximum stress (MPa) in *Onlay* and *Endocrown* restorations with a 45º force on enamel and dentin.

	Onlay	*Endocrown*
200 N	60,8	65,9
500 N	145,9	164,8
800 N	233,3	263,6

Regarding the stress distribution in the tooth with the restoration, the results of both 11º and 45º forces demonstrate a similar pattern between the two groups, where the *Onlay* restoration shows better results than *Endocrown* (Table II and Table III).

Concerning the stress distribution in enamel and dentin, in all the models where an 11º force was applied, the *Onlay* restoration evidenced more stress areas with higher stress values when comparing the with the *Endocrown*. On the other hand, when dealing with a 45º force, the *Onlay* restoration shows better results than the *Endocrown* (Table IV and Table V).

The area where the stress distribution is higher in the *Endocrown* is in the remaining buccal wall in all groups while on the *Onlay* restoration, the stress accumulation is located on the lingual and cervical area.

In the forces applied at 45º there is higher stress concentration in the models when comparing with an 11º force, as well as when an 800N force is applied comparing with 200N.

Discussion

When an endodontic treatment is needed, the vitality loss has an impact in the physical properties of dentin such as micro-hardness, modulus of elasticity and fracture resistance. There are some changes in the tubule density that decrease towards the apex. The steps from endodontic therapy such as the access cavity, the canal widening or the use of several chemicals can, significantly, reduce the resistance of the tooth[(1)] and the literature reports the absence of the marginal bridges as the main reason for the loss of structural strength[(4)].

Tooth fracture is a well-known concern for all dentists. This fracture can happen for two reasons: iatrogenic causes such as loss of tooth structure, effect of chemicals or intra-canal medication or problems in the restoration; and not iatrogenic causes such as anatomical position of the tooth or the effect of age of tooth tissue[(20)].

According to what is reported in various studies, the conservation of remaining hard tissue is crucial when dealing with non-vital teeth, as it improves the mechanical stability and increases the available areas for making a good adhesion, which has a positive impact on the long-term results of the treatment[(21-23)].

The introduction of adhesive techniques has revolutionized the restoration of endodontically treated teeth, since it is no longer necessary to take the mechanical retention into account , but instead rely on micromechanical and molecular retention provided by the adhesive procedure. Bearing this in mind, the more area between the tooth and the restoration (interface area), the higher probability of survival of the restoration[(24)].

It is reported in previous literature that, regardless of the restoration type used, endodontically treated premolars can´t reach the fracture resistance of sound teeth. However, there are ways to increase this resistance, such as cusp reduction and coverage with the restoration. In a study made by Bitter et al. it is reported that the restoration of cavities with remaining palatal and buccal wall using *Onlays* with cusp coverage is better than with *Inlays* without it[(21, 25)].

The precision of the models is crucial for obtaining valid results in a Finite Element Analysis (FEA) study. This type of study consists of a computer model of a material or design in which a force is applied and analysed. FEA studies are an approximation to the reality, since many details are idealized, simplified or ignored. The loading model is an approximation of what happens *in vivo* in terms of boundary conditions or the material properties. Still, FEA analysis models and simulations have been used for many years to study the biomechanical behaviour of materials and structures where these variables are impossible to measure directly. Moreover, many of the FEA studies already confirm the laboratory ones. In this study, a 3-D model was created to evaluate the distribution of functional stress between two types of restorations, *Endocrown* and an *Onlay* with a resin build-up. This type of model is better than a 2-D model, which may not represent the tooth irregularities and may neglect several important details(17).

The VM stress distribution was used in this study to analyse the images, as it is the combination of the absolute values squared of all stresses and it is reported in most of the previously published studies. This type of stress (VM) is widely used as an indicator of the possible damage that can occur on a material. Another parameter also used in this study to analyse the results was the maximum stress values, because when it comes to brittle materials such as bone or ceramics, it is suitable for better indicating the magnitude of stress concentrations and allowing the comparison with the ultimate compressive and ultimate tensile strengths of a material(17, 26).

Analysing the results of this study regarding the stress distribution in the restored models, the *Onlay* configuration showed better outcomes at 11º and 45º. The results observed on enamel and dentin with a 45º force may occur because the resin build-up better distributes or absorbs the stress caused by the force applied to the tooth than a ceramic monoblock *Endocrown would* without this resin layer. In a in vitro study made by Magne et al. it is concluded that the use of a small composite resin build-up may be useful because it can provide enhanced geometry, remove undercuts from the endodontic preparation and facilitate provisionalization when it is needed(27). Another study form Rocca et al. demonstrates that the insertion of a resin-coating layer may reduce the risk of extensive fractures and improve the success rate on non-vital teeth(28).

Since high stiffness materials like ceramics generate high stress values with a negative influence in the biomechanical behaviour of the restorative system when used to replace dentin, the use of low stiffness materials as composite resins that accompany the natural flexure of the dentin, reduce the stress. This type of materials seems to be a reliable strategy to generate low stress values when used a build-up(29).

Regarding the force application at 11º and the stress distribution on the enamel and dentin, the *Endocrown* shows better results when comparing to he *Onlay* configuration, which goes along with the results of a study made by Lin et al.(3), and it can be good when restoring molars(30) because the angle of the forces applied on that type of teeth is closer to this angle. These results may be due to the fact that the *Endocrown* presents some advantages in reducing the effect of multiple interfaces of the restorative system or offering a greater ceramic thickness resistant to compression forces. In one study made by Lin et al. it is concluded that the *Endocrown* and the classical crown obtained the same results in the failure probability and fatigue-load tests, showing that the *Endocrown* is a feasible option because of its conservative preparation and aesthetic outcomes(15, 31). This conclusion was also achieved by Durand et al., reporting that models only restored by ceramic material bonded directly into the cavity showed better stress distribution than models restored with composite bases [32]. *Endocrowns* may have different materials, such as lithium dissilicate, multiphase resin or leucite-reinforced ceramic. It is reported that under axial loading lithium dissilacte ($Li_2Si_2O_5$) and multiphase resin used as *Endocrown* material presented similar results, but when it comes to lateral forces, lithium dissilicate shows better results[8, 33]. For *Onlay* configurations, lithium dissilicate showed significantly better performances than leucite based ceramics[34].

The restoration of endodontically treated premolars is widely controversial in the literature, since these teeth are under very aggressive forces. Some studies state that the use of *Endocrowns* to restore this type of teeth is feasible or satisfactory[3, 11, 31], on the other hand there are studies reporting that the addition of a pulp extension to the all ceramic restorations such as *Onlay*s or *Inlays* don't bring any biomechanical advantage to the restored teeth[35].

This study has several limitations such as the model mesh which has limitations related to the software (SolidWorks) itself that couldn´t properly connect the nodes of the model, affecting the results by creating spots on the model where a large concentration of stress was seen without any actual points of stress concentration. One of these areas was the CEJ. Other limitation is the fact that the load condition (200, 500 and 800 *Newton*), the angle and the force application point in the model are only approximations to the complex balance between the masticatory forces and their reactions. Since the occlusal forces are extremely complex, they can´t be reproduced in numeric simulations and need to be simplified as typical axial or lateral forces. The model used in this study did not represent the adhesive materials (adhesive or cement) in the interfaces because these are very small components and would require much more computing power and a different software approach. The periodontal ligament wasn't also taken in account because it is an hiper-elastic material and would require this to be a non-linear analysis, which was not the objective of this purely comparative study.

Reviewing the results of this study, the null hypothesis that there are no differences between the two studied groups was rejected, since there are variations in the stress distribution between the models restored with *Onlays* with a resin core and ceramic *Endocrowns*, in endodontically treated teeth.

Conclusion

Among the various options in restoring procedures, *Endocrowns* and *Onlays* are two possible types of restorations for endodontically treated teeth vulnerable to the masticatory forces that naturally occur in the oral cavity. These restorations try to restore the resistance of these teeth, increasing their survival rates and fracture resistance.

Within the limitations of this study, the following conclusions were drawn:

I. A 45º force applied to the long axis of the tooth always generates higher stress values in comparison with a force applied at 11º.
II. *Endocrowns* induce more stress in the remaining buccal wall, increasing the probability of cusp fracture.
III. When it comes to more destructive loads, *Onlays* with a composite resin core seem to present better results when compared to *Endocrowns*.

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Attachments

Abbreviations:

EF- Elementos Finitos.

FE- Finite Element.

ETT- Endodontically Treated Teeth.

CEJ – Cement-enamel junction.

VM- Von Mises.

FEA- Finite Element Analysis.

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