

# Filling Cavities Or Restoring Teeth?

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## Introduction

The primary function of the human dentition is preparation and processing of food through a biomechanical process of biting and chewing. This process is based on the transfer of masticatory forces, mediated through the teeth. Ensuring continued force application through tooth structures is a fundamental concern in dentistry. When a tooth structure is compromised by cariogenic activity or trauma, the original function needs to be restored. Such restoration involves both the anatomical shape and the structural integrity. While the anatomical shape ensures effective mastication and good occlusion, the structural integrity is needed for the transfer of coronal forces during masticatory function.

While intact teeth seldom fracture under normal functional loading, for intracoronally restored teeth fracture is a major concern.<sup>1-4</sup> The fact that an intact tooth seldom fractures indicates that its natural design is optimized for the intended masticatory task. This adequate performance of the tooth design is determined by the combination and strength of the dental hard tissues.<sup>5</sup> However, when a restoration is carried out, it may change the optimized coronal stress distribution. As a result, the same coronal tissues may not be able to withstand the same masticatory forces and structural failure develops. Therefore, restoration of a tooth ideally requires the recreation of the original stress distribution in the remaining tooth structure.

The two main types of intracoronally restorations are amalgam and composite. The principal biomechanical difference between the two types is that whereas composites are bonded in the cavity, amalgams are generally not. The effect of this difference on the stiffness characteristics and the predisposition to fracture is well-established.<sup>6-9</sup> Many publications have shown the loss of tooth stiffness for unbonded restorations and how it is almost recovered when

## ABSTRACT

Teeth seldom fracture under normal functional loading. This indicates that the natural tooth design is optimized for the distribution of regular masticatory forces by means of its properties and structure. When a tooth is restored with an intracoronally restoration, however, the incidence of tooth fracture increases. Since remaining tissues do not change, the restorative actions apparently alter the original stress distributions. In this study, the effect of different restoration types (unbonded amalgam and bonded composite restorations) were compared with the original stress conditions of the intact tooth, using finite element analysis. It was shown that an unbonded amalgam restoration did not restore the original stress conditions but led to much higher stresses in the buccal and lingual enamel and to higher tensile stresses in the cavity floor. The unbonded amalgam thus filled the cavity but did not restore the tooth. In contrast, a bonded composite restoration restored the original stress pattern in the tooth if there was no polymerization shrinkage. Polymerization shrinkage causes residual tensile stresses in the dentin around the cavity and in the buccal and lingual enamel. Residual tensile stresses in the buccal and lingual enamel are momentary compensated by compressive stress components during occlusal loading. It was concluded that bonding and elimination of residual stresses are prerequisites for restoring the original tooth integrity.

### CLINICAL RELEVANCE:

A restoration should restore the structural integrity. An unbonded amalgam restoration will lead to higher stresses in the tooth structure, thus it fills a cavity but does not restore a tooth. A bonded composite restoration could restore the original stress pattern in a tooth if polymerization shrinkage would not introduce residual stresses. Ideally, a restoration requires good bonding and no shrinkage/expansion stresses.

### KEY-WORDS:

Restoration, Amalgam, Composite, Stress, Shrinkage

restorations are bonded. It has also been shown that teeth with unbonded restorations fracture at lower loads. However, the matter of bonding or not bonding does not specifically change the strength of the involved tissue structures. Therefore, both the change in stiffness and the decrease in tooth strength are an indication that the stress distribution in the tooth has changed and that the tooth design is apparently not optimized for the stress distribution after restoration.

Stress represents how the masticatory forces are transferred through the tooth structure. These stresses cannot be measured directly and are therefore less easily assessed than stiffness or fracture.

But, although tooth stiffness and fracture are related to the stress conditions in the tooth, neither provides sufficiently detailed information about the stress distribution.

The objective of the current study was to calculate and visualize how a sound tooth distributes a masticatory force and how a restorative action affects this biomechanical response using numerical analysis. The significance of this study is the importance of restoring the original stress paths in a structurally-compromised tooth, considering that the structure-property relationships of the natural tooth are optimized for masticatory function.

Table 1 - Applied material properties.<sup>26</sup>

Material	Elastic modulus (GPa)	Poisson's ratio	Tensile strength (MPa)	Compressive strength (MPa)	Strength differential effect†	Critical stress ratio‡
Enamel	84.1/42.05*	0.30	10.3	384	37.3	1.00
Dentin	18.3	0.23 <sup>27</sup>	98.7	297	3.0	0.10
Amalgam	27.6	0.35	65.7	388	5.9	0.16
Composite	16.6	0.24	45.5	277	6.1	0.23

\* 84.1 GPa in the principal direction, 42.05 GPa in the transverse plane

† Compressive strength/Tensile strength

‡ Tensile strength of enamel/Tensile strength

## Materials and Methods

Stress depends on multiple factors, such as how the tooth is loaded, how the tooth is fixed, and the tooth anatomy that comprises the shape and the combination and organization of different hard tissues. For the current essay, finite element analysis was used to evaluate the stresses in a simulated tooth (MSC.Marc, MSC Software Corporation, Santa Ana, CA, USA). The execution of a finite element analysis involves discretization of the anatomy into a mesh, which is the collection of elements, the application of physical properties, forces, constraints, the solution of the mathematical model and the processing of the results.

For this analysis, a bucco-lingual cross-section of a premolar was taken as the basic anatomy to be studied. The contours of the enamel and dentin substrates of a cross-sectioned premolar were digitized (NIH Image by Wayne Rasband, Version 1.62, National Institutes of Health, USA). Three cases were modeled: a sound tooth, an amalgam restoration and a composite restoration. The bucco-lingual width of the restorations was approximately half of the distance between the buccal and lingual cusps (**Figure 1**). The finite element mesh was created by subdividing the contours into smaller shapes (elements). **Figure 2** shows the element distributions in the three study cases. A two-dimensional model was used in this finite element analysis that simulated a

plane strain condition. This engineering term identifies a three-dimensional stress condition that may occur in a tooth when the strain perpendicular to the cross-sectional plane is zero. The current model represents a bucco-lingual cross-section through the center of the occlusal portion of a tooth with a Class II MOD restoration.

Physical properties were applied by assigning properties to combinations of elements: grouped as enamel, dentin, composite/amalgam. The applied properties are summarized in **Table 1**. The anisotropic response of enamel was applied through its transverse-isotropic stiffness properties, where the principal direction was perpendicular to the dentin-enamel junction (**Figure 2**). This simulates the approximate orientation of the enamel rods. Although the microstructure of dentin is also anisotropic, it has been shown that the stiffness response is isotropic or mildly anisotropic at best.<sup>10,11</sup> Therefore, isotropic properties were applied for dentin, which means that its physical properties were independent of orientation. The properties for amalgam and composite are isotropic. To demonstrate the effect of anisotropic enamel properties on the stress distribution, the analyses were repeated with an isotropic enamel assumption with an elastic modulus of 84.1 GPa. Since the purpose of the current study was a qualitative assessment of stress distributions, which did not

pretend to simulate failure loads, it was not necessary to model non-linearity and plasticity relationships. All stress-strain relationships were therefore modeled linear-elastic.

The composite was modeled to be well-bonded to the tooth, but there was no bonding between the amalgam and the tooth structure. The coefficient of friction between the amalgam and tooth tissues was 0.60 and the contact separation force was 1 N, simulating interfacial roughness. The amalgam restoration was kept in place by the mechanical undercut, while a prescribed tying between nodes in the cavity floor and the restoration ensured sufficient boundary conditions without allowance of tensile stresses across the interface. A slight amalgam setting expansion of 0.01% (linear) was modeled. The composite restoration simulated a bulk-filled auto-curing system with a polymerization shrinkage value of 0.2% (linear post-gel shrinkage). Since the plane strain conditions prevent shrinkage in the perpendicular plane, thereby overestimating the constraints and thus shrinkage stress in the composite, shrinkage was only simulated in the cross-sectional plane. Additionally, a hypothetical non-shrink composite was simulated for demonstration purposes. The composite was bonded inside a conservative tooth cavity with rounded margins. The thin adhesive and cementum layers were regarded as part of their main substrates, composite and

dentin, respectively. Pulp tissues were not simulated since they do not significantly contribute to the mechanical response of a tooth.

To demonstrate the structural integrity of the tooth structure under influence of masticatory forces, a 40 N occlusal load was applied by means of a simulated opposing cusp that touched both cuspal inclines. The force was effectively distributed through contact forces on both the buccal and lingual cuspal inclines (**Figure 2**). The properties of the opposing cusp simulated those of enamel. The coefficient of friction between the opposing cusp and the tooth was 0.50. The tooth models were fixed at the bottom, at the level of the gingival margin. This fixation ensured coherence between the buccal and lingual root segments in this cross-sectional model. The sub-gingival root was not modeled since the objective was to demonstrate the stress distribution in the crown around the restoration. Note that according to the de Saint-Venant Principle<sup>12</sup>, stress concentrations caused by the constraints will quickly decrease away from the fixation, i.e., in the crown.

### Results

The 40 N occlusal force was distributed through the simulated premolar via two occlusal contact points. The stress distributions in the sound tooth and the various restorations are shown in **Figure 3**, where stress values are indicated according to a linear color scale: blue colors indicating the lowest and yellows the highest stress values. The figure displays equivalent stresses according to the Von Mises criterion, which integrates all stress components from three dimensions into one equivalent stress value.

The stress distribution for the sound tooth shows high stress concentrations at the occlusal contact points and a gradual stress attenuation through the buccal and lingual enamel (**Figure 3A**). Stress levels rise again at the cemento-enamel junction. The amalgam restoration causes a large increase in the stresses in the enamel and dentin (**Figure 3B**). Furthermore, a new area of high stresses is generated at the cavity floor and corners. Restoring the tooth with a hypothetical non-shrink composite results in a stress distribution similar to the conditions shown in the sound tooth (**Figure 3C**). When

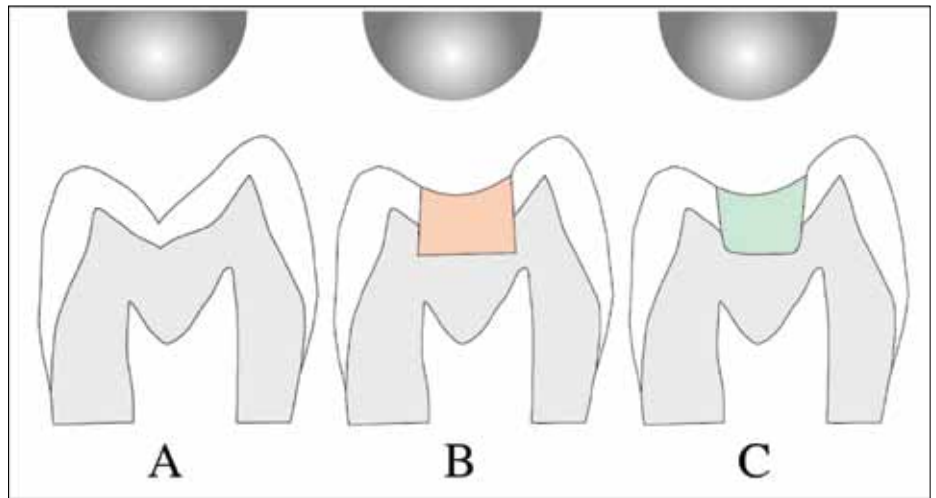


Figure 1 - Bucco-lingual cross-section of a restored premolar used for the finite element modeling of three designs: (A) intact tooth, (B) tooth with amalgam restoration, and (C) tooth with composite restoration. The simulated opposing cusp used to apply an occlusal load is drawn above the three designs.

polymerization shrinkage is simulated, residual stresses are generated in the tooth structure around the restoration and at the buccal and lingual enamel surfaces before the occlusal load is applied (**Figure 3D**). When the occlusal load is applied, the stress distribution in the composite restored premolar increases in the enamel and dentin, especially around the restoration, while the stresses at the buccal and lingual enamel surfaces shift sub-surface (**Figure 3E**).

The stress calculations were repeated

for models in which enamel properties were assumed to be isotropic in order to demonstrate the effect of more simple material property definitions (**Figure 4**). The figure illustrates that the assumption of isotropic enamel properties had very little effect on how the stresses distributed. In general, the stress level in the enamel was slightly higher and in the dentin slightly lower compared to the results obtained with transverse-isotropic properties (**Figure 3**).

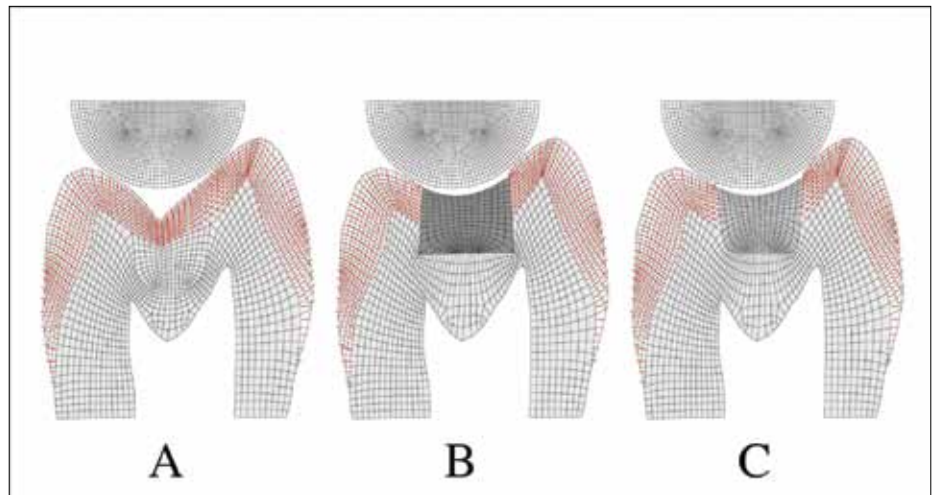


Figure 2 - Finite element mesh distributions created by subdividing the tooth contours and simulated opposing cusp into smaller shapes (elements): (A) intact tooth, (B) tooth with amalgam restoration, and (C) tooth with composite restoration. The principal enamel rod orientation is shown in red. Transverse enamel orientation is the plane perpendicular to the principal direction.

## Discussion

The primary function of teeth is mechanical. Restoration of a compromised tooth thus implies preservation of the mechanical response, which is how masticatory forces are transferred. Since the stress represents how those forces are distributed through the tooth, evaluation of mechanical behavior involves the study of stress distributions. Stress depends on multiple factors, such as how the tooth is loaded and where it is fixed, and the tooth anatomy which comprises the shape and the combination of different hard tissues. Assessment of the stresses in a tooth is thus a complex task, which was achieved with the help of finite element analysis.<sup>13</sup> In a finite element analysis, the complex system (the tooth) is solved by subdividing it into a series of interrelated simpler problems, which subsequently can be solved.

### Model definitions

Obviously, since stress values depend on so many variables, the final results of stress calculations depend on the assumptions made in the study. The anatomy used in this analysis was based on the cross-section of an actual premolar, while the occlusal cavities can be considered representative of the two restoration types (unbonded amalgam and bonded composite). In reality, teeth and restorations come in many shapes, each combination will affect the quantitative

results.<sup>14,15</sup> Likewise, the applied occlusal load was only one option out of an infinite number of possibilities, while tissue properties also vary from tooth to tooth. Consideration of natural variation is a reality in any biomedical research endeavor, not only in numerical analyses, and consequently there will seldom be a quantitative result that is universally accurate. It is therefore important to treat the current results qualitatively for the study of general principles in dental biomechanics.

Although assumptions need to be made in order to establish the anatomy, loading, and physical properties within any analysis, it is important that these assumptions are realistic and will not change the general conclusions about the tooth system response. It is interesting to note that valid results do not always require perfect model definitions. For example, although the anisotropic nature of enamel is well-known, assuming isotropic properties for the enamel would not have changed the principal insights and general conclusions for the current stress analysis (**Figure 4**). Probably the most significant assumption in the current analysis was the choice of a plane strain condition. A plane strain condition represents a three-dimensional stress situation that may occur in the cross-section of a structure with considerable thickness out of the

plane, which is true for the modeled tooth cross-section. In such cross-section the strain perpendicular to this cutting plane is zero, while the stress in the third dimension is a function of the stresses in the plane. For a bucco-lingual cross-section of the tooth, a plane strain model tends to cause a reduced stiffness since it does not incorporate bucco-lingual reinforcements of the mesial and distal tooth structure. Nevertheless, a plane strain model was selected for this analysis because it allowed a clear visual demonstration of the general principles of the effect that different restoration types have on the structural integrity of the tooth. To verify that the response of the cross-sectional tooth model was realistic, the deformations of the finite element model were compared with experimental measurements reported in the literature. Many studies have measured the deformation of cusps or buccal/lingual enamel surfaces, sometimes expressed in stiffness values such as the Relative Stiffness proposed by Morin et al.,<sup>16</sup> to assess the impact of restorative actions on tooth integrity.<sup>17-19</sup> Comparison with the reported experimental data confirmed that the values determined in the current cross-sectional plane strain model (**Table 2**) were within a realistic range.

Deformation and stiffness measurements in the literature have been successfully used to show various impacts

**Table 2 - Calculated changes in the distance between the cusps and mean vertical strains (radicular-coronal direction) at the greatest lingual and buccal convexities during a 40 N occlusal load. Positive intercusp distance values indicate cusps being moved apart, negative values indicate cusps closer together. Negative strain values indicate compressive strains. Relative Stiffness<sup>16</sup> was calculated by dividing the strain values for the sound tooth by the values after restoration.**

Model	Intercusp distance change ( $\mu\text{m}$ )	Mean strain ( $\mu\text{strain}$ )	Relative Stiffness (strain)
Sound tooth	3.0	-176	1.00
Amalgam restoration	21.4	-495	0.36
Composite restoration (no polymerization shrinkage)	2.4	-161	1.09
Composite restoration (polymerization shrinkage)	-8.3	-10	17.60 (1.17*)

\* Relative Stiffness if residual polymerization shrinkage deformation is ignored

of restorative actions. However, they are not sufficient to provide a complete understanding of the mechanical response of a restored tooth. Deformation and strain depend on the location where they are measured. Therefore, stiffness values will vary with measurement protocol and can result in misleading outcomes, depending on the choice of sensor placement. For example, **Table 2** shows that for the same tooth and load conditions, restorative procedures affected the change in intercuspal distance more than the strain on the buccal and lingual convexities. Moreover, if polymerization shrinkage deformation is not included in experimental measurements, stiffness of the tooth may seem recovered without any indication that the tooth structure is permanently stressed (**Table 2**). Therefore, to evaluate restoration of the integrity of a tooth requires further analysis of the stress conditions.

### Stress distribution in the tooth

The goal of a restoration is to restore the structural integrity of a compromised tooth. Since the strength of the remaining tooth tissues did not change, it means that any restoration should reestablish the original stress distribution (**Figure 3A**). The current analysis illustrates that an amalgam restoration may successfully restore the main anatomical contours of the tooth, but it does not restore its structural integrity (**Figure 3B**). Stresses in the amalgam restored tooth model are much higher in the enamel and dentin. Due to the cavity preparation, the tooth has lost structural hard tissues that used to take part in carrying the occlusal loads. The unbonded amalgam restoration, however, shows no stresses and thus has clearly not taken over the load that the lost tooth structure used to carry. In effect, under the loading conditions applied in this analysis, the stresses in the tooth would have the same as if the cavity would have been left empty. Furthermore, the sharp internal angles of the amalgam preparation have raised stress concentrations that were not present originally, which supports the concept of rounded line angles. It is important to note that any shift in stress concentrations may affect the fracture resistance of the tooth, because the fracture resistance of a tooth structure is optimized through specific distribution of its property and structure

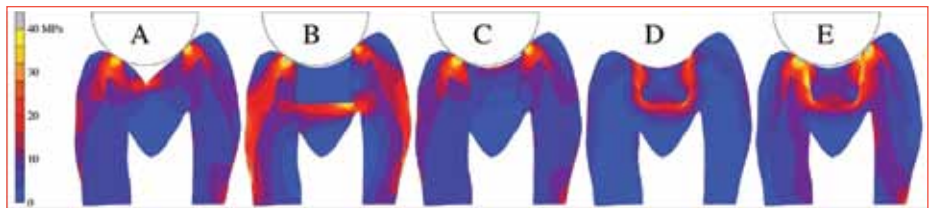


Figure 3 - Von Mises equivalent stress distributions during a 40 N occlusal load for: (A) intact tooth, (B) tooth with unbonded amalgam restoration, (C) tooth with bonded non-shrink composite restoration, (D) residual stresses in tooth with bonded shrinking composite restoration without any occlusal load, and (E) tooth with bonded shrinking composite restoration with the occlusal load.

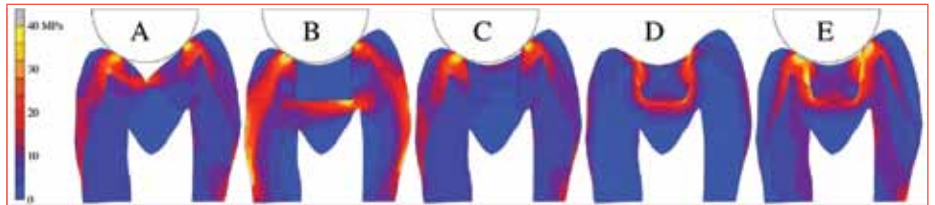


Figure 4 - Von Mises equivalent stress distributions when the enamel is assumed to be isotropic during a 40 N occlusal load for: (A) intact tooth, (B) tooth with unbonded amalgam restoration, (C) tooth with bonded non-shrink composite restoration, (D) residual stresses in tooth with bonded shrinking composite restoration without any occlusal load, and (E) tooth with bonded shrinking composite restoration with the occlusal load.

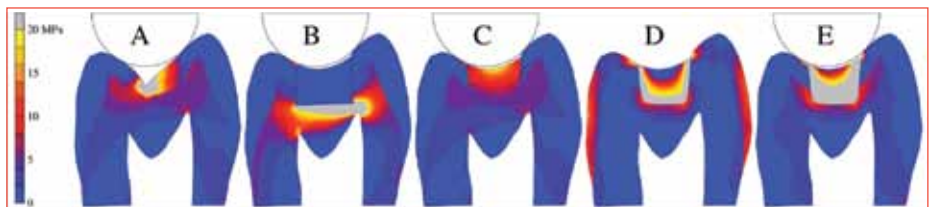


Figure 5 - Modified Von Mises equivalent stress distributions (modified to include the ratio between the compressive and tensile strengths, see Table 1) during a 40 N occlusal load for: (A) intact tooth, (B) tooth with unbonded amalgam restoration, (C) tooth with bonded non-shrink composite restoration, (D) residual stresses in tooth with bonded shrinking composite restoration without any occlusal load, and (E) tooth with bonded shrinking composite restoration with the occlusal load.

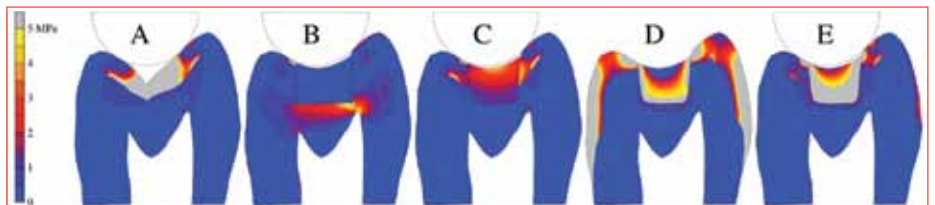


Figure 6 - Critical modified Von Mises equivalent stress distributions (modified to include the ratio between the compressive and tensile strengths and adjusted for the critical stress ratio, see Table 1) during a 40 N occlusal load for: (A) intact tooth, (B) tooth with unbonded amalgam restoration, (C) tooth with bonded non-shrink composite restoration, (D) residual stresses in tooth with bonded shrinking composite restoration without any occlusal load, and (E) tooth with bonded shrinking composite restoration with the occlusal load.

relationships.<sup>5</sup> The main reason why the amalgam falls short in restoring the tooth is because it lacks a bonded interface. The amalgam was therefore a successful filling of the cavity, rather than a restoration. Unlike an unbonded interface, bonding allows the transfer of tensile stresses and is also much more efficient in the transfer of shear stresses. This is clearly demonstrated by the example of the non-shrink composite restoration, which almost exactly restored the original stress distribution in the tooth structure (**Figure 3C**). Unfortunately, although great progress is being made in the formulation of new restorative composites, current composites continue to shrink during polymerization. The adhesive bond that was shown to be essential for restoring the structural integrity (**Figure 3C**) also causes residual shrinkage stresses in composite restored teeth. These stresses are called residual because they cause stresses in the tooth even when there is no functional load (**Figure 3D**). Adding an occlusal load creates complex stress distributions that again do not recreate the original stress conditions (**Figure 3E**). Therefore, even though a composite restores the tooth contour and the adhesive bonding allows the composite to take part in carrying and distributing occlusal loads, as long as polymerization shrinkage remains a significant factor, composite does not restore the structural integrity of a tooth.


True restoration implies the exact recreation of the original stress distribution. Although this is the goal, not all changes in stress conditions have equal weight because the tooth structure is able to withstand compressive stresses better than tensile stresses (**Table 1**). Since the Von Mises equivalent stress relationship does not distinguish between tensile and compressive stresses, not all new stress concentrations shown in **Figure 3** are equally critical. Note that although a tooth is subjected to a compressive occlusal force, tensile stresses are also generated in the tooth structure. The Von Mises criterion can be modified to incorporate the ratio between the compressive and tensile strength (**Table 1**). Based on this ratio, tensile stresses can be given more weight in a modified Von Mises criterion.<sup>20-23</sup> **Figure 5** shows the redrawn stress distributions using the modified Von Mises criterion. Areas

with predominant tensile stresses now show up as more acutely stressed. The figure shows a highly tensile environment at the fissure of the intact tooth (**Figure 5A**). This tensile condition is exacerbated by the choice of the plane strain model, which considers the fissure as a deep trench rather than a pit surrounded by higher mesial and distal ridges. Other areas with tensile stresses are located below the amalgam restoration (**Figure 5B**) and the buccal and lingual enamel surfaces for the residual stresses in case of the composite restoration (**Figure 5D**). The residual tensile stresses in the buccal and lingual enamel are actually counteracted by the occlusal load, practically eliminating them in this simulation at the 40 N force level (**Figure 5E**). This dynamic would create a predominantly tensile cyclic stress condition in the enamel walls during masticatory functioning, as opposed to the intact tooth or the amalgam restored tooth where the buccal and lingual enamel would encounter a predominantly compressive cyclic stressing (which is generally a less critical stress component). Note that the residual shrinkage case is always stressed, even when there is no functional loading, while the other cases would be stress free without an occlusal load.

**Figure 5** showed the stress distributions according to the Von Mises equivalent stress modified to express the different sensitivities to tensile stresses of each tissue. However, the stress distribution uses the same stress scale for the different tissues. It is clear from **Table 1** that different tissues reach their critical strength at different stress levels. For example, enamel reaches its ultimate strength at about 10 MPa, while dentin has only reached about 10% of its tensile strength at that stress level. In order to make an evaluation of the most critical areas easier, the modified Von Mises equivalent stresses were multiplied with a critical stress ratio, which can be defined as each material's tensile strength normalized with respect to enamel (**Table 1**). **Figure 6** shows the stress distributions redrawn for the critical modified Von Mises stress values. Von Mises stresses in **Figure 3** were useful for illustrating the stress distributions, while the critical modified Von Mises stresses in **Figure 6** are useful for showing critical areas for

structural failure. Note that the shown stress concentrations are not necessarily the areas where the tooth will fail, since fracture properties depend on more variables than only the tensile stress levels, but they illustrate areas where the chance for failure is probably highest given the applied loading conditions. Most strikingly, the figure visually depicts the critical clinical concern about residual polymerization stresses that may cause significant tensile stress areas in the buccal and lingual enamel, and occlusal restoration margins (**Figure 6D**). It should be noted that the amount of residual polymerization stresses depends on many factors<sup>14,15,24</sup>, including cavity size and shape, curing technique and composite properties. Moreover, residual stresses may reduce over time due to relaxation of viscoelastic effects and hygroscopic expansion of the restorative resin<sup>25</sup>, or due to failure of the adhesive interface. Therefore, the results of this study should be considered qualitatively rather than quantitatively, where they illustrate that while a bonded restoration is essential for recovering the original structural integrity, residual stresses may prevent real restoration to be achieved with current adhesive resin-based restorative materials.

## Conclusions

A tooth is adequately designed to manage normal masticatory loading through the combination of its tissue properties and the distribution of the ensuing stresses. When the structural design becomes compromised, restorative actions should be focused on recreating the original stress distributions. In this analysis it was shown that to restore the original stress pattern in a structurally compromised tooth requires a bonded restoration that does not create residual stresses. 

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## Questions for Continuing Education Article - CE Exam #30

1. What is the goal of a restoration:
  - a. To restore the structural integrity of the compromised tooth
  - b. To make it cosmetically beautiful
  - c. To repair the damage
  - d. None of the above
2. The main reason amalgam falls short in restoring the structural integrity of the tooth is because:
  - a. It lacks a bonded interface
  - b. It contains mercury
  - c. It is not cosmetic
  - d. It percolates at the cavo-surface angle
3. The stress distribution for a sound tooth shows high stress concentration at:
  - a. The proximal contact points
  - b. The occlusal contact points
  - c. The buccal aspect
  - d. The lingual aspect
4. In a finite element analysis, the complex system (the tooth) is solved by subdividing it into what:
  - a. A series of interrelated simpler problems
  - b. A binary adaptation
  - c. A quadratic equation
  - d. A geometric equation
5. The engineering term that identifies a three-dimensional stress condition that may occur in a tooth when the strain is perpendicular to the cross-sectional plane is zero is:
  - a. Linear expansion
  - b. Linear contraction
  - c. Brinell hardness
  - d. Plane strain

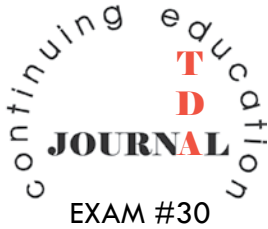
*Publication date: Spring 2011. Expiration date: Spring 2014.*

# Answer Form for TDA CE Credit Exam #30:

*Filling Cavities or Restoring Teeth?*

Publication date: Spring 2011. Expiration date: Spring 2014.

Circle the correct letter answer for each CE Exam question:



1.	a	b	c	d
2.	a	b	c	d
3.	a	b	c	d
4.	a	b	c	d
5.	a	b	c	d

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