

# A Comparative Finite Element Analysis of Stress Distribution On Maxillary First Molar Tooth Having PEEK And Metal Crown Opposing Natural Mandibular First Molar Tooth During Mastication Of 3 Varied Denseness Morsels

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## ABSTRACT

**Aim** - To compare and evaluate the stress distribution in porcelain fused to metal and dual ceramic polymer crowns on mandibular molar with anatomical and non-anatomical tooth preparation opposing maxillary molars by using Finite Element Analysis.

**Material and method** - Finite element analysis was performed using ANSYS 18.1 on a three-dimensional mandibular first molar model. Four crown designs were evaluated: PFM and dual-ceramic polymer crowns with anatomical and non-anatomical preparations. A static load of 400 N was applied, distributed as 200 N on the buccal cusp tip and 200 N along the central developmental groove. The cement layer was neglected, and enamel was assumed to be completely removed. Materials were assumed homogeneous, isotropic, and linearly elastic, with properties derived from literature.

**Result** - Finite element analysis under 400 N load showed higher stress concentration in PFM crowns at cervical margins and occlusal contacts. Dual-ceramic polymer crowns exhibited more uniform stress distribution with lower peak values. Non-anatomical preparations increased stress at axial walls and root apex, while polymer crowns demonstrated superior biomechanical performance.

**Conclusion** - PFM crowns showed higher stress concentration at occlusal and cusp regions. Dual-ceramic polymer crowns distributed stress more evenly but transmitted some stress to underlying dentin. Anatomic tooth preparation reduced stress concentration and provided better biomechanical performance compared to non-anatomical preparation..

**Keywords:** Finite Element Analysis, Peek Crown, Metal Crown, Stress Distribution Pattern

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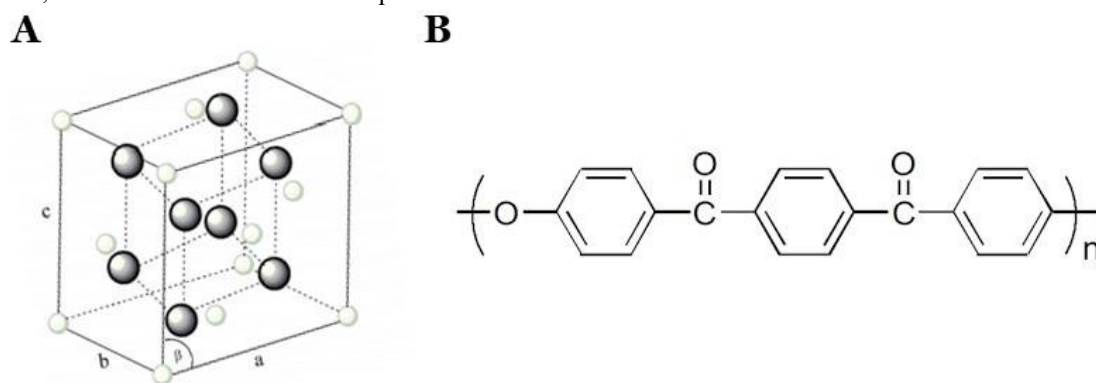
## INTRODUCTION

In dentistry, tooth fractures are a major problem since they frequently result in circumstances that cannot be restored, particularly in posterior teeth like mandibular first molars.<sup>1</sup> Because of their anatomical structure, lingual cusps break more frequently than buccal cusps. Due to their durability and long-term success, metal alloy crowns especially those made of gold were once frequently used.

However, their use has decreased as a result of growing expenses and cosmetic issues. Because of their greater mechanical strength, biocompatibility, and aesthetic appeal, metal-free ceramic restorations particularly zirconia<sup>2</sup> [Fig – 1A] have grown in favour. Additionally, fibre-reinforced composite (FRC) restorations have showed encouraging outcomes, exhibiting steady marginal adaptation over time and strong fracture resistance.<sup>3</sup> Furthermore, and their wear behaviour is quite similar to

that of genuine enamel. For posterior tooth rehabilitation, advances in restorative materials often yield better functional and cosmetic results.

Polyetheretherketone (PEEK) and polyether-ketoneketone (PEKK) combine to form polyaryletherketone (PAEK), which has recently been utilised in dentistry. Recently, the dental industry was exposed to high-performance, chemically inert biomaterials called PEEK and PEKK. Because of its extremely low propensity to generate an allergy, PEEK has comparatively few known systemic immunological reactions after intraoral insertion. Compared to conventional, well-researched veneering ceramics and denture base resin materials, PEEK has superior mechanical properties and less discolouration. [Figure 1B]<sup>4</sup>



**Figure 1. Structure of zirconia (A) and polyetheretherketone (PEEK) (B). Modified from.**

Because of its advantageous mechanical qualities, PEEK is being utilised more frequently in fixed dental prostheses as a substitute for PMMA and composite resins. Better stress absorption is made possible by its low elastic modulus, and its great colour stability and less enamel erosion improve clinical performance. Strength and appearance are further enhanced by modified forms, such as PEEK reinforced with carbon and glass fibre. Additionally, PEEK has outstanding heat stability and chemical resistance, which makes it appropriate for long-term use. Occlusion, muscular activity, and periodontal health are some of the elements that affect mastication. Finite element analysis (FEA) studies comparing stress distribution in various restorations are still scarce, despite the widespread usage of materials like zirconia, ceramics, and gold alloys.<sup>3,4</sup>

This study evaluates stress patterns in maxillary first molars restored with PEEK and metal crowns under varying food consistencies to determine their biomechanical performance and suitability for posterior restorations.

### AIM:

To evaluate the stress distribution pattern on maxillary first molar having PEEK & METAL crowns with opposing natural tooth of mandibular first molar while masticating 3 different morsels.

### OBJECTIVES:

1. To evaluate the stress values on maxillary first molar crown models made of two distinct materials. (PEEK & METAL).
2. To evaluate maximum pressure on the occlusal surface during mastication of 3 different morsels.
3. To calculate stress components (Tensile stresses, shear stress, Compressive stresses) for analysis of stress distribution on two different crown materials. (PEEK & Metal).

### Material:

The present study utilized finite element analysis (FEA) to evaluate and compare stress distribution beneath the occlusal surfaces of PEEK and metal crowns. Standardized tooth preparations were digitally modelled to ensure consistency. Three-dimensional models were created using Solid Edge v19, meshed with Hypermesh v11, and analysed in ANSYS v18.1 under simulated occlusal loading. The computational setup included a system with 8 GB RAM, 500 GB storage, and a 4 GB graphics card for efficient processing. The analysis provided valuable insights into the biomechanical performance of both materials, highlighting differences in stress distribution and their functional behaviour under loading conditions.

### Method:

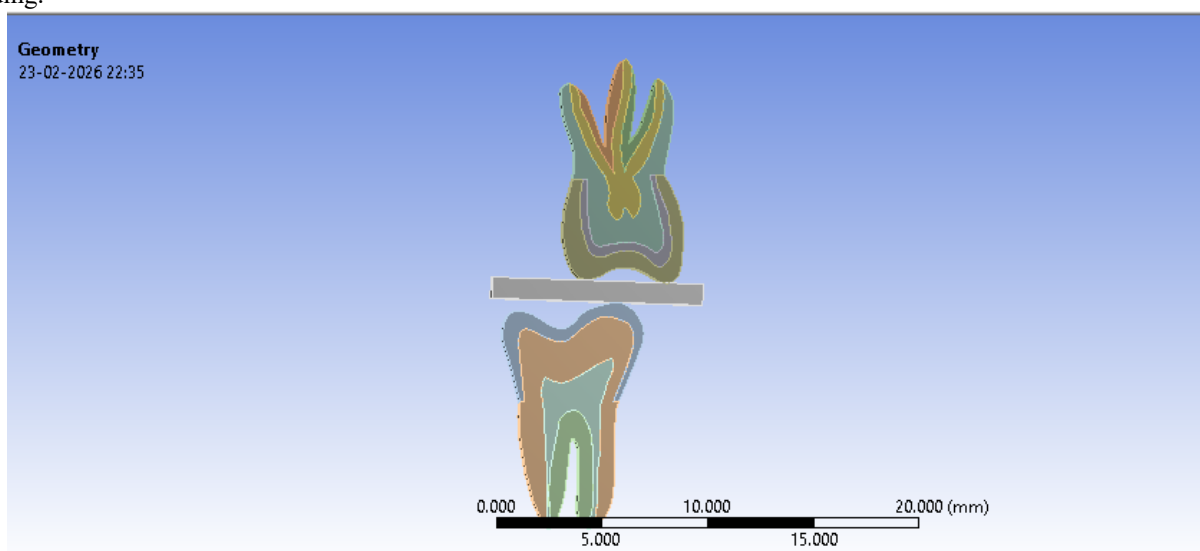
A combination of ANSYS software and finite element analysis (FEA) was used to evaluate stress distribution in maxillary first molars during functional articulation.<sup>1</sup> FEA

is a widely accepted numerical method for simulating the complex biomechanical behaviour of dental structures under functional loading conditions.<sup>2</sup> Using this approach, stress magnitudes and distributions within tooth tissues and prosthetic crown materials were assessed under simulated masticatory forces.<sup>4</sup>

A detailed anatomical model of the maxillary first molar was developed based on established literature,<sup>5,6</sup>The modelling was performed in the frontal plane, as it is most suitable for analysing stress patterns generated during lateral and vertical masticatory movements.<sup>7,8</sup> Key structural components, including enamel, dentin<sup>6</sup>, pulp space, and root morphology, were accurately reproduced to closely mimic natural tooth anatomy. Special emphasis was placed on the cuspal inclines and fissure patterns due to their significant role in stress concentration under occlusal loading.<sup>9,11</sup>

To simulate physiological conditions, a periodontal ligament (PDL) layer of 0.1 mm thickness was incorporated around the root surface.<sup>12</sup> The PDL plays a critical role in load transmission and stress dissipation between the tooth and surrounding alveolar bone.<sup>13</sup> Its viscoelastic nature allows slight tooth movement under load, thereby influencing stress distribution within both the crown and tooth structure. Although modelled as a homogeneous layer for computational simplicity, its inclusion enhances the biological accuracy of the analysis.

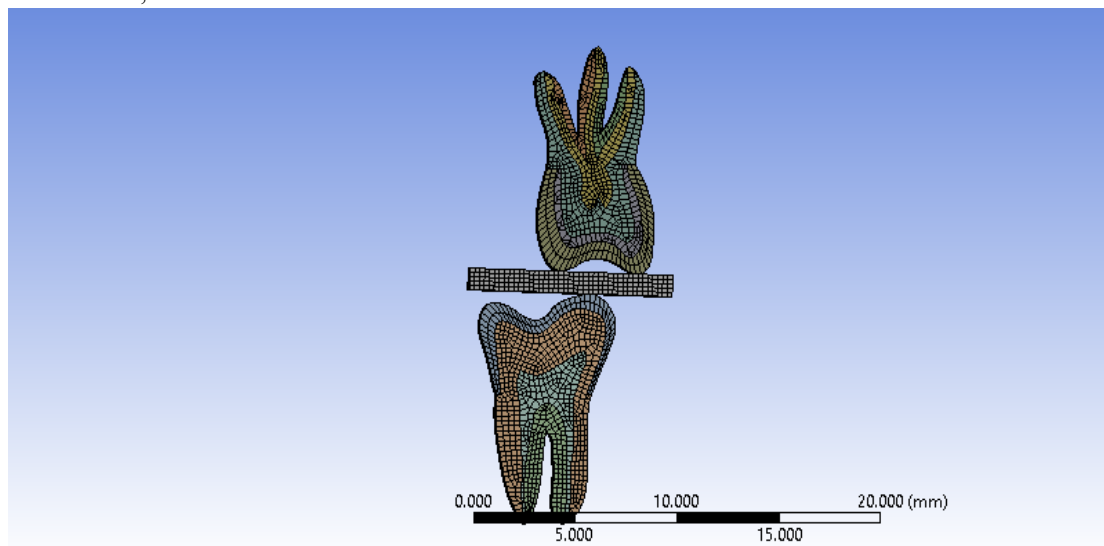
Additionally, an opposing mandibular molar was modelled to replicate realistic occlusal interactions.<sup>14</sup> Both teeth were positioned to simulate mastication involving three different food particles, enabling a more accurate representation of functional chewing dynamics.<sup>15</sup>



**Figure 2:- CAD Model**

The crown and tooth models were discretized into 9360 rectangular finite elements connected by 54,482 nodes to enable computational analysis.<sup>16</sup> The analysis assumed a plane stress condition, suitable for two-dimensional models

where thickness is small compared to other dimensions. Accordingly, stresses perpendicular to the plane were considered negligible and set to zero.<sup>1, 17, 20</sup>



**Figure 3:- Meshed Model**

Boundary conditions were applied to stabilize the model and ensure realistic deformation and stress distribution. The maxillary molar was fixed at the periodontal bone interface<sup>18</sup>, preventing rigid body motion.<sup>17</sup> Tooth preparation followed standard prosthodontic principles, and cementation was simulated as a perfectly bonded interface without slippage. Mechanical properties including elastic

modulus, Poisson's ratio, and density were assigned to enamel<sup>6</sup>, dentin<sup>6</sup>, periodontal ligament, stainless steel, and PEEK based on literature. All materials were assumed homogeneous, isotropic, and linearly elastic to simplify finite element analysis and enable valid comparison between prosthetic materials.

	Elastic Modulus (MPa)	Poisson's ratio	Density (g/cm <sup>3</sup> )
ENAMEL	83000	0.33	3.00
DENTINE	18600	0.31	2.12
PERIODONTIUM	68.9	0.45	0.22
MORSEL I (Bone)	10000	0.28	2.0
MORSEL II (Liver) <sup>23</sup>	0.04	0.50	1.06
MORSEL III (Carrot)	15	0.30	1.01
PEEK CROWN	4000	0.38	1.32
STAINLESS STEEL	193000	0.31	7.93

**Table 1:- Mechanical properties of materials used in models of first maxillary molar and first mandibular molar as well as crowns and 3 different morsels.**

Three standardized morsels (1 × 1 mm) were incorporated to simulate mastication under varying food consistencies. Their elastic moduli were altered to represent hard (bone-like), soft (liver-like), and moderately stiff (carrot-like) food materials, enabling evaluation of stress transmission through the crown-tooth complex under different functional conditions.<sup>19,20</sup> A computer-simulated chewing cycle was performed in the frontal plane to replicate physiological mastication<sup>21</sup>, with morsels positioned between opposing molars to mimic crushing and grinding. For computational purposes, the mandibular molar was considered fixed, while the maxillary molar underwent movement. A lateral displacement of 1.5 mm and a vertical load of 124 N were applied to approximate physiological masticatory forces.<sup>8,10,21</sup> Contact interactions between occlusal surfaces and morsels were defined with a friction coefficient of 0.05, and non-linear analysis was performed using incremental loading and automatic time stepping to ensure convergence and numerical stability. In addition to dynamic loading, static loading conditions were simulated by applying three vertical forces of 124 N along the long axis at clinically relevant occlusal contact points.<sup>21</sup> Stress components including compressive, tensile, and shear stresses were evaluated to compare the biomechanical behaviour of PEEK and stainless steel crowns.

Results were presented as colour-coded stress distribution patterns on frontal sections of molar crowns, facilitating

comparison of stress concentration zones. These findings provide insights into how material properties and food

consistency influence stress distribution, aiding in the selection of restorative materials and optimization of prosthodontic treatment outcomes.

**Result:**

**MAXILLARY FIRST MOLAR WITH PEEK CROWN**

- **Concentration Points:** Highest stress (orange/yellow) occurs at the contact interface between the lower tooth and horizontal plate.
- **Mandibular First Molar:** Marked stress gradient at the occlusal surface indicates force application at the cusp-plate contact.
- **Maxillary First Molar:** PEEK crown appears mostly green, indicating lower shear stress in the X-Y plane.
- **Morsel (Bone):** A hotspot (yellow/orange) in the center suggests pinching and shear between teeth.
- **Stress Values:** Maximum tensile stress is 522.88 MPa and peak compressive stress is -912.88 MPa.
- **Stress Distribution:** Hotspots occur at cusp-morsel contact; teal/blue areas indicate compressive stress zones.
- **Morsel (Bone):** Intense local deformation indicates high risk of failure under a 124 N load.

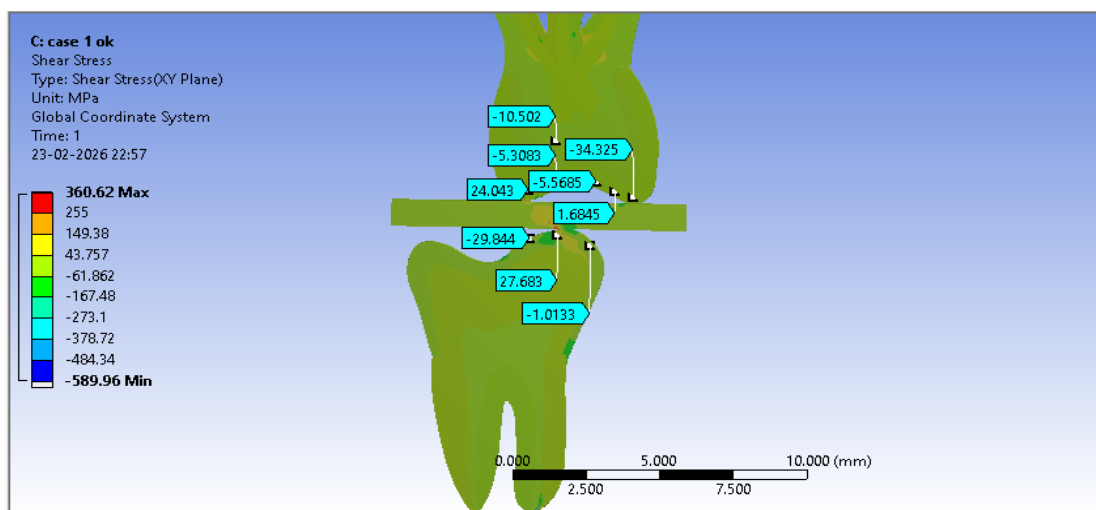


Figure 4:- Probed result

**Maxillary First Molar with PEEK crown:** - Stress values near the buccal cusp and crown tip is -34.325 MPa. Stress values near the slops of buccal cusps are 1.6845 MPa, -5.5685 MPa. Stress at central fossa is -5.3083 MPa. Stress at palatal cusp 24.043MPa. These negative values suggest the direction of the shear vector.

**Mandibular First Molar (Lower):** Probes on the mandibular molar show a mix of positive and negative shear, with a buccal cusp point at **27.683 MPa**. This indicates a complex "pinching" effect where the material is being pulled in different directions across the tooth surface.

**CASE II - MORSEL II (LIVER)**

**Stress values:** 736.99 MPa to -1208 MPa. The negative value indicates the direction of the shear vector.

**Observation:** The peak stress is concentrated at the **contact point** between the maxillary first molar PEEK crown palatal cusp, the morsel II (Liver) and mandibular first molar buccal cusp.

**Stress values:** 150.78 MPa. To -141.18 MPa. The negative value indicates the direction of the shear vector.

**Observation:** The stress distribution is more "global" and uniform across the maxillary first molar PEEK crown and tooth structure, though the highest values remain at the point of impact.

**Stress values:** - Maximum (Tensile) Stress 1072.2 MPa (Red). This indicates areas where the material is being "pulled apart." Minimum (Compressive) Stress -1867.9 MPa (Dark Blue). This indicates the highest crushing or "squeezing" forces. The negative value indicates the direction of the shear vector.

**Stress Distribution:** - The stress at this load is concentrated at the immediate contact points between the maxillary first molar PEEK crown palatal cusp and the Morsel II (Liver), and the mandibular first molar buccal cusp.

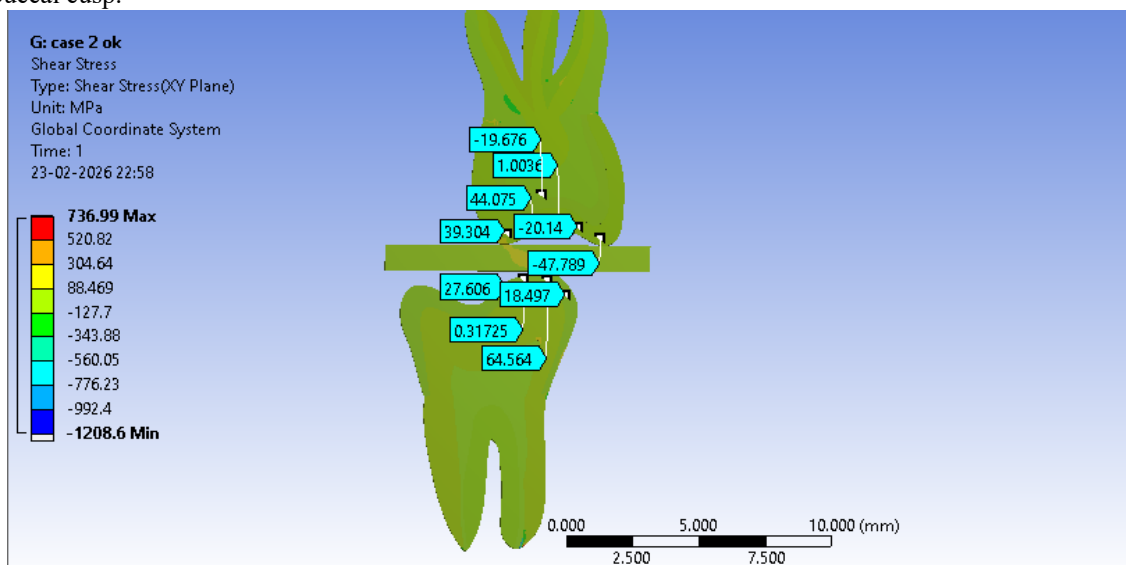


Figure 5:- Probed result

**Maxillary First Molar with PEEK crown:** - Stress values near the buccal cusp and crown tip is -47.789 MPa. Stress values near the slops of buccal cusps are -20.14 MPa,

1.0036 MPa. Stress at central fossa is 44.075 MPa. Stress at palatal cusp 39.304MPa. These negative values suggest the direction of the shear vector.

**Mandibular First Molar (Lower):** Probes on the mandibular molar show a mix shear stress, with a buccal cusp point at 64.564 MPa. This indicates a complex stress distribution in different directions across the tooth surface.

**CASE III – MORSEL III (CARROT)**

**Stress values:** 696.67 MPa to -1142.2 MPa. The negative value indicates the direction of the shear vector.

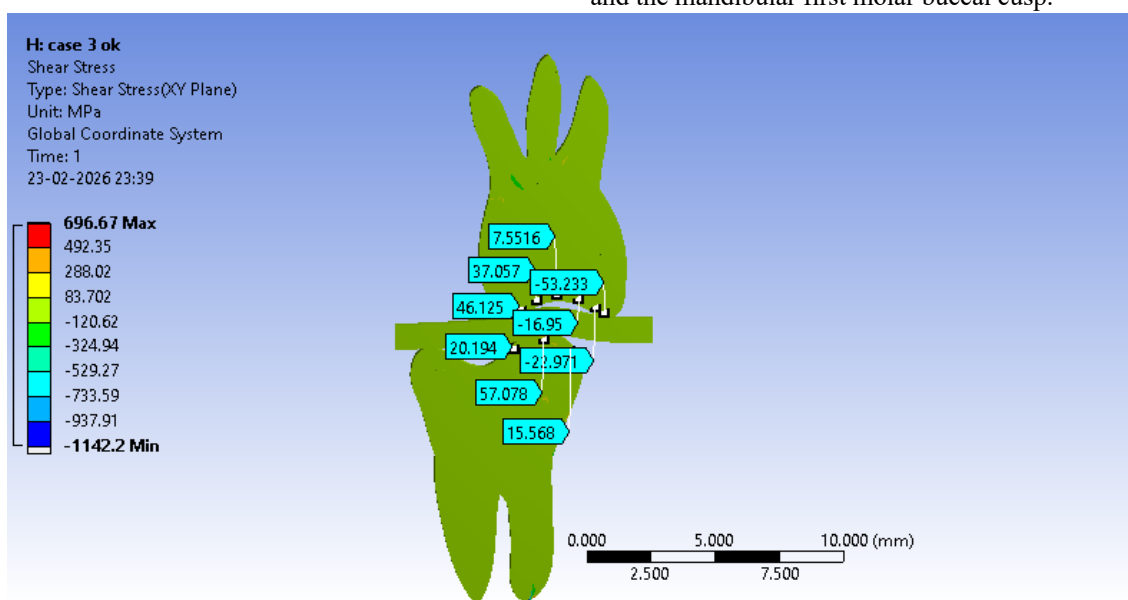
**Observation:** The peak stress is concentrated at the contact point between the maxillary first molar PEEK crown palatal cusp, the morsel III (Carrot) and mandibular first molar buccal cusp.

**Stress values:** 142.48 MPa. To -110.73 MPa. The negative value indicates the direction of the shear vector.

**Observation:** The stress distribution is more "global" and uniform across the maxillary first molar PEEK crown and tooth structure, though the highest values remain at the point of impact with morsel III (Carrot).

**Stress values:** - Maximum (Tensile) Stress 1013.3 MPa (Red). This indicates areas where the material is being "pulled apart." Minimum (Compressive) Stress -1765.5 MPa (Dark Blue). This indicates the highest crushing or "squeezing" forces. The negative value indicates the direction of the shear vector.

**Stress Distribution:** - The stress at this is concentrated at the immediate contact points between the maxillary first molar PEEK crown palatal cusp and the Morsel III (Carrot), and the mandibular first molar buccal cusp.



**Figure 6:- Probed result**

**Maxillary First Molar with PEEK crown:** - Stress values near the buccal cusp and crown tip is -53.233 MPa. Stress values near the slops of buccal cusps are -16.95 MPa, -22.971 MPa. Stress at central fossa is 7.5516 MPa. Stress at palatal cusp 46.125 MPa. These negative values suggest the direction of the shear vector.

**Mandibular First Molar (Lower):** Probes on the mandibular molar show a mix shear stress, with a buccal cusp point at 57.078 MPa. This indicates a complex stress distribution in different directions across the tooth surface.

**MAXILLARY FIRST MOLAR WITH STAINLESS STEEL CROWN**

**Simulation Type:** The analysis was at the steady-state response of the materials to the 124 N load, rather than a dynamic impact or vibration.

The bottom indicates the teeth are approximately **10–15 mm** in height, which is anatomically accurate for human molars.

**Loading Protocol:** Maxillary First molar with Stainless steel Crown opposing natural Mandibular first molar tooth.

**CASE IV - MORSEL I (BONE)**

**Stress values:** 168.4 MPa to -256.78 MPa. The negative value indicates the direction of the shear vector.

**Observation:** The high stress is concentrated at the contact point between the maxillary first molar Stainless steel

crown palatal cusp, the morsel I (Bone) and mandibular first molar buccal cusp.

**Stress values:** 57.192 MPa. To -55.508 MPa. The negative value indicates the direction of the shear vector.

**Observation:** The stress distribution is more "global" and uniform across the maxillary first molar Stainless steel crown and tooth structure, though the highest values remain at the point of impact with morsel I (Bone).

**Stress values:** - Maximum (Tensile) Stress 601.42 MPa (Red). This indicates areas where the material is being "pulled apart." Minimum (Compressive) Stress -1365.6 MPa (Dark Blue). This indicates the highest crushing or "squeezing" forces. The negative value indicates the direction of the shear vector.

**Stress Distribution:** - The stress is concentrated at the immediate contact points between the maxillary first molar Stainless steel crown palatal cusp and the Morsel I (Bone), and the mandibular first molar buccal cusp.

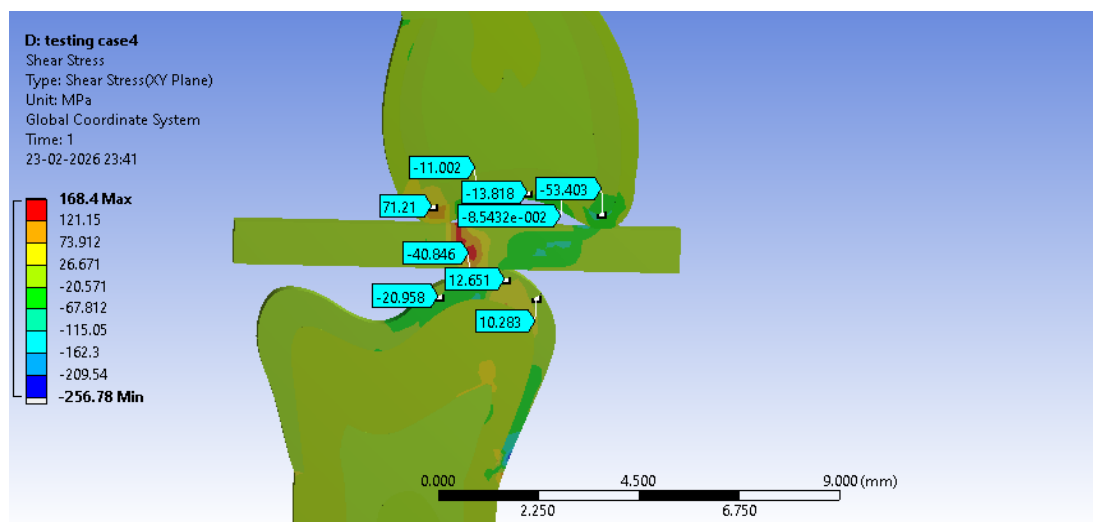


Figure 7:- Probed result

**Maxillary First Molar with Stainless Steel crown:** - Stress values near the buccal cusp and crown tip is -53.403 MPa. Stress values near the slops of buccal cusps are -8.5432 MPa, -13.818 MPa. Stress at central fossa is -11.002 MPa. Stress at palatal cusp 71.21 MPa. These negative values suggest the direction of the shear vector.

**Mandibular First Molar (Lower):** Probes on the mandibular molar show a mix shear stress, with a buccal cusp point at 12.651 MPa. This indicates a complex stress distribution in different directions across the tooth surface.

**CASE V - MORSEL II (LIVER)**

**Stress values:** 417.14 MPa to -391.48 MPa. The negative value indicates the direction of the shear vector.

**Observation:** The stress is concentrated at the contact point between the maxillary first molar Stainless Steel crown palatal cusp, the morsel II (Liver) and mandibular first molar buccal cusp.

**Stress values:** 86.839 MPa. To -55.828 MPa. The negative value indicates the direction of the shear vector.

**Observation:** The stress distribution is more "global" and uniform across the maxillary first molar Stainless Steel crown and tooth structure, though the highest values remain at the point of impact.

**Stress values:** - Maximum (Tensile) Stress 1028.7 MPa (Red). This indicates areas where the material is being "pulled apart." Minimum (Compressive) Stress -2079.8 MPa (Dark Blue). This indicates the highest crushing or "squeezing" forces. The negative value indicates the direction of the shear vector.

**Stress Distribution:** - The stress at this load is concentrated at the immediate contact points between the maxillary first molar stainless steel crown palatal cusp and the Morsel II (Liver), and the mandibular first molar buccal cusp.

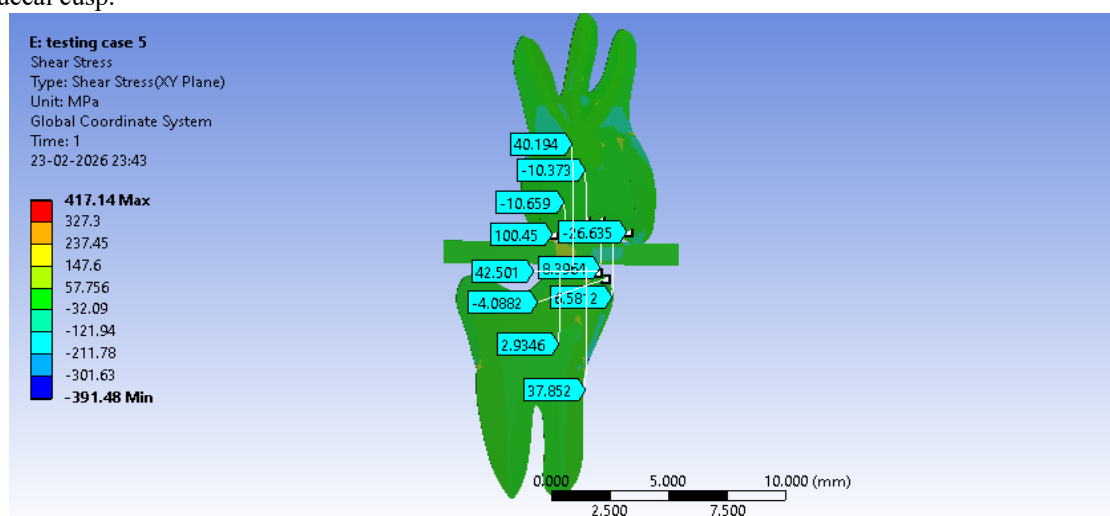


Figure 8:- Probed result

**Maxillary First Molar with Stainless Steel crown:** - Stress values near the buccal cusp and crown tip is -26.635 MPa. Stress values near the slops of buccal cusps are 6.5272 MPa, 8.3964 MPa. Stress at central fossa is -10.659 MPa.

Stress at palatal cusp 100.45 MPa. These negative values suggest the direction of the shear vector.

**Mandibular First Molar (Lower):** Probes on the mandibular molar show a mix shear stress, with a buccal

cusps point at 42.501 MPa. This indicates a complex stress distribution in different directions across the tooth surface.

**CASE VI – MORSEL III (CARROT)**

**Stress values:** 473.28 MPa to -389.17 MPa. The negative value indicates the direction of the shear vector.

**Observation:** The peak stress is concentrated at the contact point between the maxillary first molar Stainless steel crown palatal cusp, the morsel III (Carrot) and mandibular first molar buccal cusp.

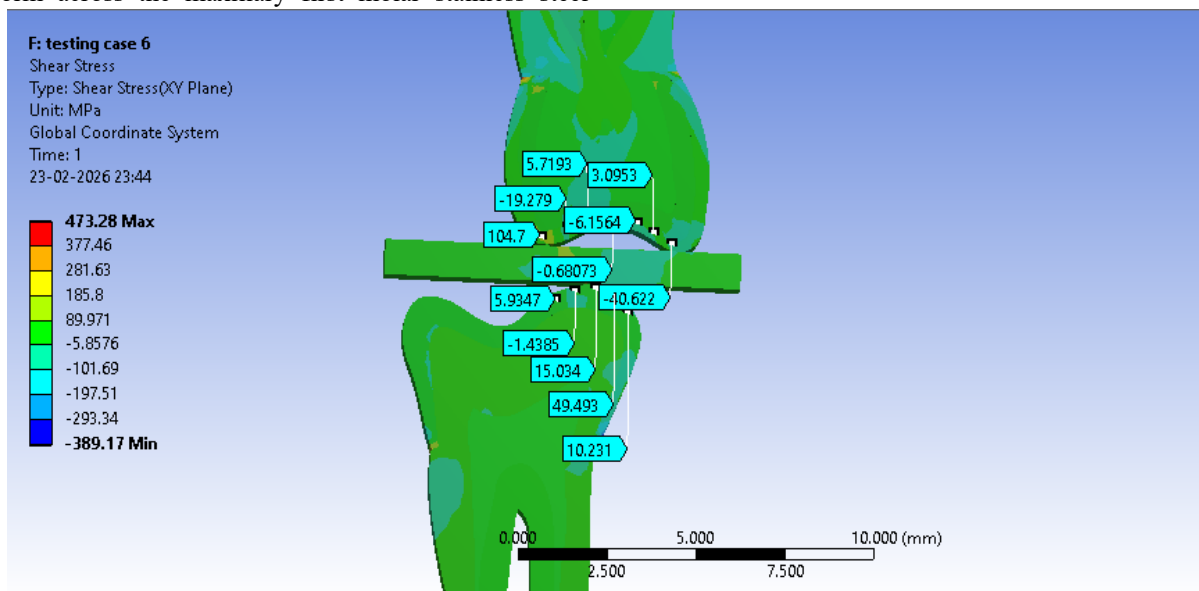
**Stress values:** 86.333 MPa. To -55.44 MPa. The negative value indicates the direction of the shear vector.

**Observation:** The stress distribution is more "global" and uniform across the maxillary first molar stainless steel

crown and tooth structure, though the highest values remain at the point of impact with morsel III (Carrot).

**Stress values:** - Maximum (Tensile) Stress 1009.9 (Red). This indicates areas where the material is being "pulled apart." Minimum (Compressive) Stress -2067.6 MPa (Dark Blue). This indicates the highest crushing or "squeezing" forces. The negative value indicates the direction of the shear vector.

**Stress Distribution:** - The stress at this is concentrated at the immediate contact points between the maxillary first molar Stainless steel crown palatal cusp and the Morsel III (Carrot), and the mandibular first molar buccal cusp.



**Figure 9:- Probed result**

**Maxillary First Molar with PEEK crown:** - Stress values near the buccal cusp and crown tip is -40.622 MPa. Stress values near the slopes of buccal cusps are 3.0953 MPa, -6.1564 MPa. Stress at central fossa is 5.7193 MPa. Stress at palatal cusp 104.7 MPa. These negative values suggest the direction of the shear vector.

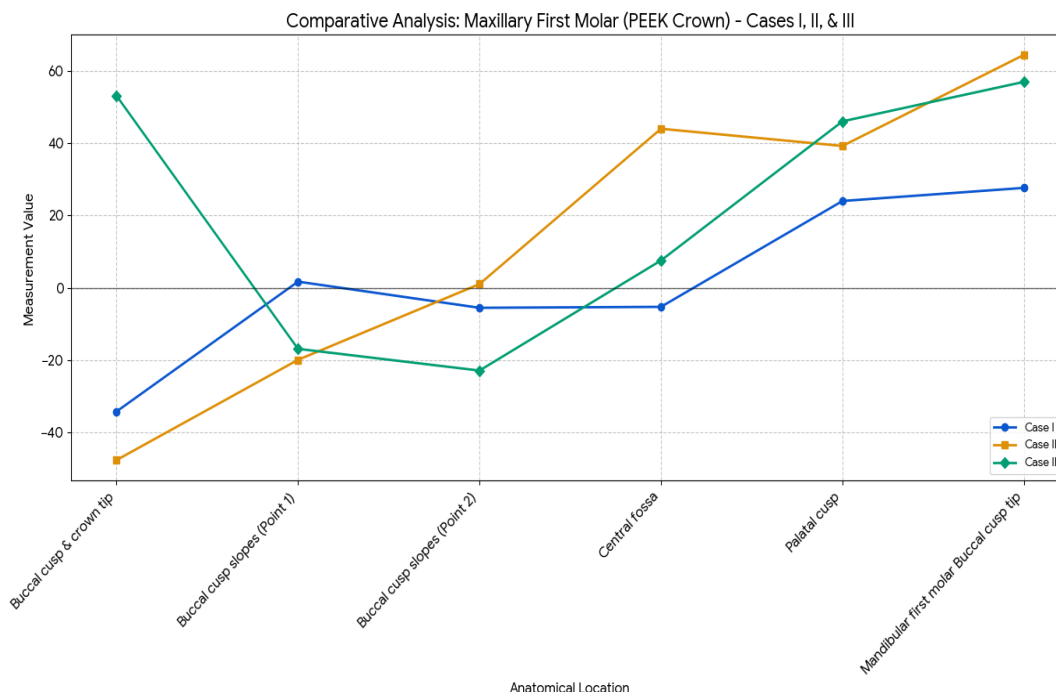
**Mandibular First Molar (Lower):** Probes on the mandibular molar show a mix shear stress, with a buccal cusp point at 49.493 MPa. This indicates a complex stress distribution in different directions across the tooth surface.

**Statistical analysis:-**

Maxillary first molar (PEEK Crown)	Case I (Bone)	Case II (Liver)	Case III(Carrot)
Buccal cusp & crown tip	-34.325 MPa	-47.789 MPa	53.233 MPa
Buccal cusp slopes (Point 1)	1.6845 MPa	-20.14 MPa	-16.95 MPa
Buccal cusp slopes (Point 2)	-5.5685 MPa	1.0036 MPa	-22.971 MPa
Central fossa	-5.3083 MPa	44.075 MPa	7.5516 MPa
Palatal cusp	24.043MPa	39.304 MPa	46.125 MPa
Mandibular first molar Buccal cusp tip	27.683 MPa	64.564 MPa	57.078 MPa

**Table 2 – Stress distribution at maxillary first molar with PEEK crown opposing mandibular first molar natural tooth while masticating 3 different morsels.**

A Comparative Finite Element Analysis of Stress Distribution On Maxillary First Molar Tooth Having PEEK And Metal Crown Opposing Natural Mandibular First Molar Tooth During Mastication Of 3 Varied Denseness Morsels



**Graph 1: Comparison of Stress distribution pattern in maxillary first molar with PEEK crown & mandibular first molar buccal cusp while masticating 3 different morsel.**

Three loading conditions—Case I (Bone), Case II (Liver), and Case III (Carrot)—were used to evaluate stress distribution in a maxillary first molar restored with a PEEK crown. Mean stress, standard deviation (SD), and range were calculated for each anatomical region.

At the buccal cusp and crown tip, the mean stress was -9.63 MPa (SD = 54.23 MPa), with a wide range of -47.789 MPa to 53.233 MPa, indicating high variability and stress reversal. Buccal cusp slopes showed predominantly compressive stresses: Point 1 had a mean of -11.80 MPa (SD = 11.85 MPa; range -20.14 to 1.6845 MPa), while Point 2 showed -9.18 MPa (SD = 12.60 MPa; range -22.971 to 1.0036 MPa).

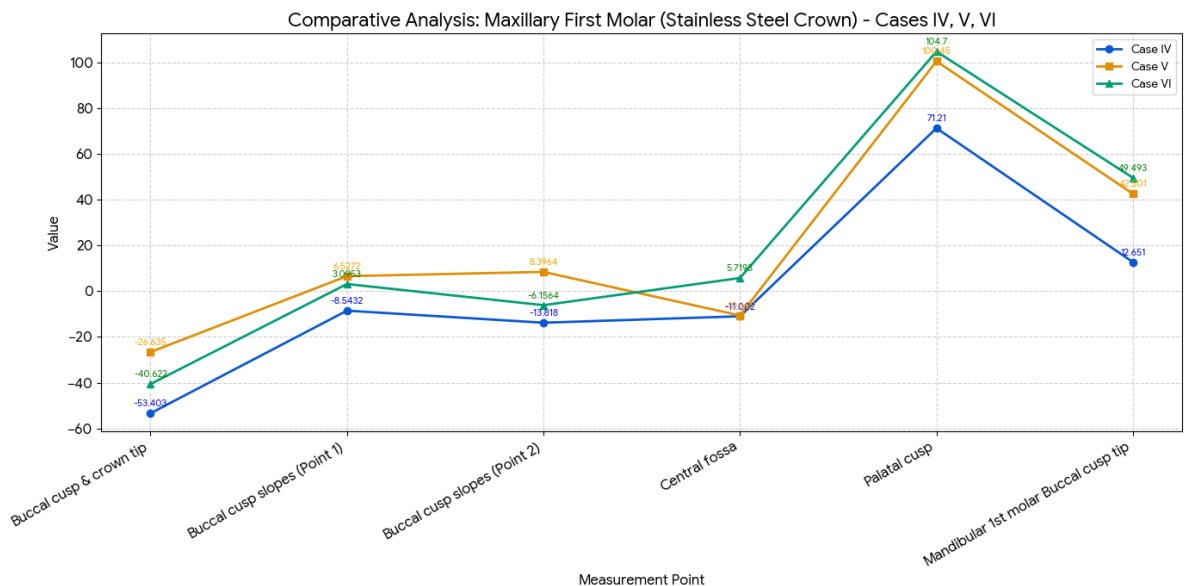
At the central fossa, the mean stress was 15.44 MPa (SD ≈ 25.50 MPa), ranging from -5.3083 MPa to 44.075 MPa, reflecting considerable variation. The palatal cusp demonstrated consistent tensile stresses with a mean of 36.49 MPa (SD = 11.35 MPa) and a narrower range of 24.043–46.125 MPa.

The highest stresses were observed at the buccal cusp tip of the mandibular first molar, ranging from 27.683 MPa to 64.564 MPa, with a mean of 49.78 MPa (SD ≈ 19.39 MPa). Overall, the palatal cusp exhibited uniform stress distribution, whereas the buccal cusp and central fossa showed greater variability, indicating the significant influence of occlusal load direction on stress patterns in PEEK crowns.

Maxillary first molar (Stainless steel Crown)	Case IV (Bone)	Case V (Liver)	Case VI (Carrot)
Buccal cusp & crown tip	-53.403	-26.635	-40.622
Buccal cusp slopes (Point 1)	-8.5432	6.5272	3.0953
Buccal cusp slopes (Point 2)	-13.818	8.3964	-6.1564
Central fossa	-11.002	-10.659	5.7193
Palatal cusp	71.21	100.45	104.7
Mandibular first molar Buccal cusp tip	12.651	42.501	49.493

**Table 3 – Stress distribution at maxillary first molar with Stainless steel crown opposing mandibular first molar natural tooth while masticating 3 different morsels.**

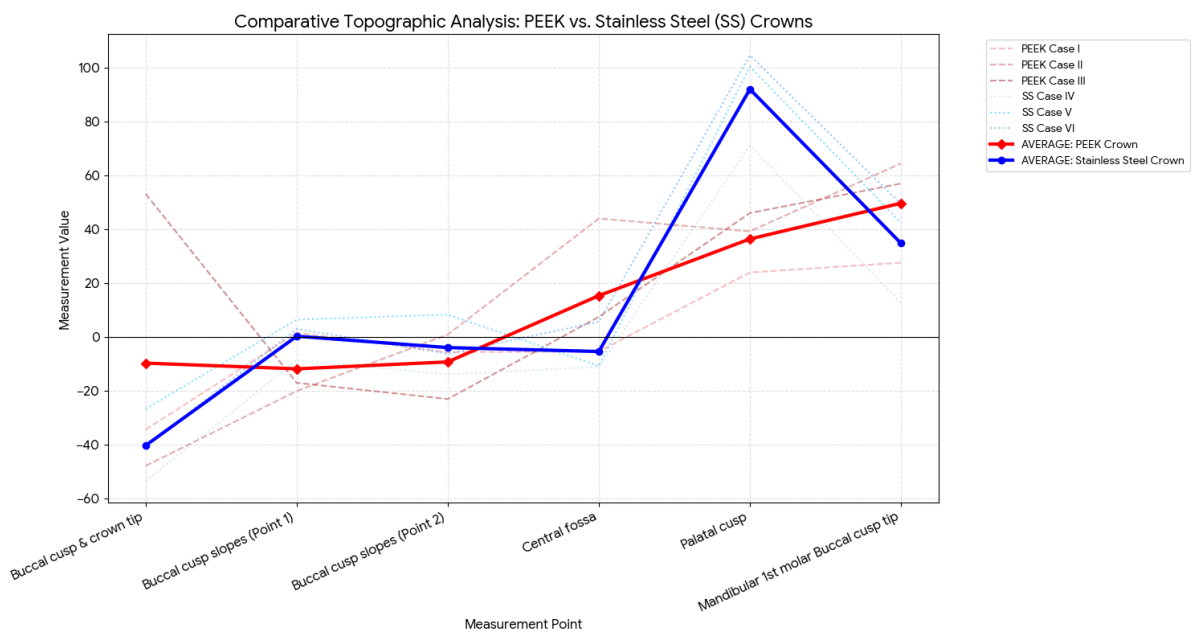
# A Comparative Finite Element Analysis of Stress Distribution On Maxillary First Molar Tooth Having PEEK And Metal Crown Opposing Natural Mandibular First Molar Tooth During Mastication Of 3 Varied Denseness Morsels



**Graph 2: Comparison of Stress distribution pattern in maxillary first molar with PEEK crown & mandibular first molar buccal cusp while masticating 3 different morsel.**

Three simulated loading conditions—Case IV (Bone), Case V (Liver), and Case VI (Carrot)—were used to evaluate stress distribution in a maxillary first molar restored with a stainless steel crown. Mean stress, standard deviation (SD), and range were calculated for each anatomical region. At the buccal cusp and crown tip, the mean stress was  $-40.22$  MPa (SD  $\approx 13.47$  MPa), with values from  $-53.403$  MPa to  $-26.635$  MPa, indicating predominantly compressive stresses. Buccal cusp slopes (Point 1) showed a mean of  $0.36$  MPa (SD =  $7.77$  MPa; range  $-8.5432$  to  $6.5272$  MPa), reflecting low and variable stress. Point 2

demonstrated greater variability, with a mean of  $-3.86$  MPa (SD  $\approx 11.39$  MPa; range  $-13.818$  to  $8.3964$  MPa). At the central fossa, the mean stress was  $-5.31$  MPa (SD =  $9.61$  MPa), ranging from  $-11.002$  MPa to  $5.7193$  MPa, indicating moderate stress concentration. The buccal cusp tip of the mandibular first molar showed increasing stress under loading, with a mean of  $34.88$  MPa (SD  $\approx 19.41$  MPa) and a range of  $12.651$  MPa to  $49.493$  MPa. Overall, the buccal cusp slopes and central fossa exhibited lower and more variable stress distribution, whereas the palatal cusp showed the highest and most consistent stress concentration under different loading conditions.



**Graph 3: Comparison of PEEK vs Stainless steel crown**

Statistical analysis revealed distinct stress distribution patterns between the two crown materials. PEEK crowns

showed variable stress patterns, with both compressive and tensile stresses, particularly at the buccal cusp and central fossa. The mandibular first molar cusp exhibited high stress

concentration, while the palatal cusp showed relatively consistent positive stress. In contrast, stainless steel crowns demonstrated higher and more consistent tensile stresses at the palatal cusp, along with predominantly compressive stresses at the buccal cusp. Overall, PEEK crowns exhibited more variable stress distribution, whereas stainless steel crowns showed greater stress magnitudes.

**Discussion:** The finite element analysis demonstrated distinct differences in stress patterns between PEEK and stainless steel crowns. In PEEK crowns (Cases I–III), stress distribution showed a combination of compressive and tensile values, indicating controlled deformation and effective energy absorption. At the buccal cusp and crown tip, stresses ranged from  $-47.789$  MPa to  $53.233$  MPa, reflecting variation with loading conditions. Buccal cusp slopes exhibited moderate stress levels, suggesting efficient stress dispersion along cusp inclines. The central fossa showed variable stress values, while the palatal cusp maintained consistent tensile stress within a controlled range ( $24.043$ – $46.125$  MPa). Stress transmitted to the opposing mandibular molar remained within physiologic limits.

In contrast, stainless steel crowns (Cases IV–VI) demonstrated higher stress magnitudes and more localized concentration. The buccal cusp and crown tip showed predominantly compressive stresses, while cusp slopes and central fossa exhibited lower but variable values. Notably, the palatal cusp recorded significantly higher tensile stress ( $71.21$ – $104.7$  MPa), nearly double that of PEEK.

Overall, PEEK crowns showed more uniform stress distribution and lower peak concentrations, whereas stainless steel crowns exhibited greater rigidity and stress localization, increasing the risk of structural and biological complications

**Conclusion:-** The present finite element study revealed significant differences in stress distribution between PEEK and stainless steel crowns on maxillary first molars. PEEK crowns exhibited lower and more uniform stress concentrations, particularly at the palatal cusp, due to their dentin-like elastic modulus. In contrast, stainless steel crowns showed higher and more localized stress values across functional areas. Although PEEK reduced internal crown stress, it occasionally transmitted higher stress to the opposing tooth. Overall, PEEK demonstrated superior biomechanical behavior with better stress modulation, suggesting it as a promising alternative to stainless steel crowns, potentially reducing the risk of structural failure and biological complications

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