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Original Article

Peri-Implant Stress Distribution in Maxillary "All-On-4" Prostheses Fabricated on Multi-Unit Angled Abutments with Cobalt Chromium Framework versus Those with Polyether Ketone (PEEK) Framework: A 3D Finite Element Analysis

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Abstract

Aim: To compare the peri-implant stresses produced by a maxillary all-on-four prosthesis in case of Polyetheretherketone (PEEK) framework and Cobalt-Chromium framework using finite element analysis.

Subjects and methods: This analysis used three-dimensional finite element models of an edentulous maxilla. Four implants were installed, then an implant supported prosthesis was fabricated. While the posterior implants were positioned at the second premolar location with a 17-degree distal angulation, the anterior implants were positioned vertically and bilaterally in the lateral-canine area. All of the implants had multi-unit abutments. A PEEK framework was designed for the first model, while a Cobalt-Chromium framework was intended for the second. The Von Mises stress, maximum stress, and directional deformation were assessed in the peri-implant bone area.

Results: PEEK frameworks transmit higher stresses to implants and abutments compared to Cobalt-Chromium, especially under oblique loading conditions. The von Mises stresses, maximum principal stresses, and directional deformation were measured, revealing that PEEK frameworks exhibited higher stress values overall. This finding highlights significant material selection considerations in implant design, emphasizing the need for careful evaluation of material properties to ensure optimal performance and longevity of dental prosthetic frameworks.
Conclusion: Both Cobalt Chromium and PEEK frameworks fabricated for an all-on-four prosthesis is considered to be a reliable treatment option for an edentulous maxilla.

Keywords: frameworks, stress, Cobalt Chromium, PEEK, dental implant.

I. INTRODUCTION

Most of the issues with traditional complete dentures have been resolved with implant-retained overdentures. Overdentures held in place by implants are noticeably more comfortable, stable, and retentive. They also allow for better chewing, which improves the patient's quality of life and satisfaction (Dwivedi, 2017).

Despite the fact that implant supported fixed prosthesis wouldn’t be indicated for all completely edentulous patients, because of in adequate width and height of residual alveolar bone for implant installation. This would require augmentation that is in some cases a major procedure for elderly patients. The concept of all on four was introduced at the first time by Paulo et al. 2005 have been the treatment of choice for severely resorbed maxillary or mandibular arches that would require a fixed implant supported prosthesis, where fully edentulous ridges are rehabilitated using fixed restorations on four dental implants, two implants inserted on the anterior jaw region in a vertical direction (i.e. 0°), while the other two are placed in the posterior region of the alveolar ridge in a distal angulation ranging between (17° to 45°) (Jemt and Book, 1996). The predictability and safety of all on four concepts have been reported by (Paulo et al. 2005; Lee and Saponaro, 2019).

When using the all-on-four concept, there is a great impact based on the choice of the material of the multi-unit abutment (Kan et al. 1999; Sahin and Çehreli, 2001). Because of its wide shoulder, which facilitates easy placement of the prosthetic restoration, the multi-unit abutment is recommended in cases where there is little interocclusal space (Wadhwani, 2016). Additionally, it comes in a variety of collar heights and is utilized for a range of soft tissue anatomies, including 0°, 15°, 30°, and 45° angled and straight.

The material used for the prosthetic framework plays a crucial role in the transmission of occlusal forces and stress to the underlying implants and the surrounding peri-implant alveolar bone (Bhering et al. 2016). For implant-supported full-arch prosthetic surgeries, a frame material with sufficient tensile strength (>300 MPa) and elastic modulus (>80 GPa) must be used in order to prevent cantilever deformation. The most frequently used material for this is the CoCr (Cobalt-Chrome) alloy. Because of their biocompatibility, low cost, low density, and favorable mechanical properties, PEEK and a Cobalt-Chromium alloy are commonly used as prosthetic framework materials. One of the most popular metals for use as a framework structure material is Cobalt-Chromium alloy. However, several issues with the CoCr alloy, including aesthetic issues and a metallic taste, were identified in multiple studies and other metal materials probably face similar issues (Tan et al. 2012).

The organic polymers that makeup nonmetal denture framework materials have a diverse range of physical and chemical characteristics. The dental industry is constantly looking for improved materials that can address the shortcomings of the ones that are now available. PEEK, a semi-crystalline organic polymer with stable chemical properties, high biocompatibility, high temperature resistance, and easy mechanical processing properties, can be used to improve the anti-allergic property, polishability, low plaque affinity, and wear resistance of nonmetal materials (Tan et al. 2012). Clinicians looking for an enhancement over traditional dental materials may find all these qualities of PEEK to be quite appealing.

This in vitro study compared the peri-implant stresses produced by PEEK and Cobalt Chromium frameworks for a maxillary all-on-four implant-supported prosthesis, utilizing finite element analysis.

II. SUBJECTS AND METHODS

Using a cone beam computed tomography (CBCT) image of a patient with an edentulous maxilla, Materialize MIMICS software was used to construct a 3D surface model of the maxillary jaw. Anatomical structural segmentation was made possible by thresholding. In this investigation, compact and cancellous bones were examined. The three-dimensional reconstruction was exported as an STL binary file.

Bio-CAD Modeling

The Reverse engineering of STL The MIMICS-based CT image segmentation approach resulted in two STL models, mentioning the cancellous and compact bone. For additional smoothing, these STLs were loaded into 3-Matic Medical 11.0 (x64) and exported in STL format. Moreover, exported as solid components prepared for Boolean subtraction and assembly in Ansys finite element analysis software, then loaded into Geomagic Design x software for reverse engineering.

Three-dimensional modeling of Implants and screws.

A Zimmer implant measuring 4.1 mm in diameter and 10 mm in length was exported as an STL file extension from the implant library of the Blueskybio software. This created a bridge between the implant's outer and inner shells and threaded the implant's interior to accept a screw with identical dimensions and thread design. The implant was then solidified. Solidworks 2016 was used to create the screw, which was then exported as a solid file.

Using an interference detection tool, all solid components were assembled and entered into the Ansys program. First, the cancellous and compact bone segments were put together inside one another. Second, the computer guide stent was appropriately seated on the compact bone for every model that was imported. Thirdly, implants were imported and placed into each model at the proper angle and bone level through the guide stent holes. To create flawless osteotomies, a Boolean subtraction of the implants from compact and cancellous bone was then performed.

The posterior implants were placed in the second premolar region with a 17-degree distal angulation, and the anterior implants were placed vertically in the lateral-canine area bilaterally, all implants had multi-unit abutments. For the first model, a PEEK structure was created, and for the second, a Cobalt-Chromium framework was proposed.

The framework, which measured [42.5 mm] by [22.5 mm], was covered with an acrylic prosthesis made out of acrylic flanges after being positioned correctly inside the implant's internal connection. The final sculpture was formed by placing acrylic teeth on top and using screw pieces to tighten the structure.

Defining the contact conditions

It was assumed that every contacting structure had 100% contact at the interface. The "contact/Gap" attribute was used to define the type of contact that existed between the components. According to (Figure 1), the contacts might be classified as "bonded" or "slip (no penetration)".

Bonded contact interface: This kind of contact was identified as existing between the implant and bony components, the gingiva and metal framework, and the cortical and cancellous bony sections. Interface for slip (no penetration) contact: This kind of contact was identified as being between the retaining screw complex, the metal framework, and the implant (Figure 1).

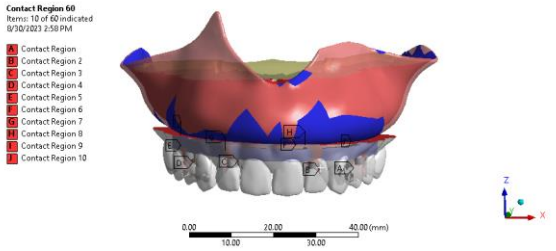


Figure (1): Displaying the acrylic prosthesis on top of the planned framework's bonded and slide contact interface.

Meshing

During this procedure, each model was broken up into tiny components known as elements, which were connected at sites known as nodes to build a mesh structure. Parabolic tetrahedral solid elements were used to build a fine solid mesh. With a tolerance value of 0.045 and a global element size of 0.9 mm, simple unstructured tetrahedral mesh generation was specifically carried out for complex geometries. The mesh density varied with a lower than 0.2 mm element size around the implants and the peri-implant bone and widening, and a higher mesh density away from the interest. All of the components and nodes for each framework are listed in Table (1).

By narrowing the mesh size around implants and the peri-implant bone and expanding it away from the area of interest, differential meshing was used to reduce file size and the time needed to solve and perform the analysis.

Table (1): The sum of the elements and nodes for the PEEK framework, and Cobalt Chromium frameworks.

Model	Element	Node
Maxillary frameworks (PEEK)	955726	1562020
Maxillary frameworks (Cobalt Chromium)	955726	1562020

Defining the material properties

The program determined the material properties for each component, including the modulus of elasticity, ultimate strength, yield strength, compressive strength, and Poisson's ratio, based on the numbers presented in Table 2 of the literature.

Table (2): Displaying the maximum strength, yield strength, compressive strength, flexible modulus, dense Poisson's ratio, gingiva, cancellous bone, and both of the Cobalt-Chromium and PEEK frameworks that were employed.

Material	Modulus of elasticity	Poisson's ratio
Compact bone	13700 MPa	0.3
Cancellous bone	7930 MPa	0.3
Gingiva	680 MPa	0.45
Cobalt-Chromium alloy	200000 Mpa	0.29
PEEK	3600 Mpa	0.3
Ti-6Al-4V alloy (Implant, Abutment and screw)	107200 Mpa	0.3
Acrylic resin (denture base)	3000 MPa	0.30

Defining loads and restraints

Initially, the "Bolt connector" characteristic was used to apply 30 Ncm of tightening torque at the implant restoration interface, which tightened every screw on the implants. The titanium parts' defined coefficient of friction was 0.3220. Every model had identical condylar restraints. The prosthesis was loaded vertically with 100 N and bilaterally obliquely (45 ° disto-mesially) on the central fossae of the first molar and 50 N on each premolar.

Running of the analysis and collection of data

The analysis was carried out to calculate the stresses, strains, and displacements following meshing. Following the conclusion of the analysis process, the maximum principal stresses on each model's peri-implant bone were determined, while the maximum equivalent stresses (von Misses stresses) were gathered from the various zones of the implant and multiunit abutments. After that, the outcomes were tabulated and contrasted. IBM SPSS Advanced Statistics (Statistical Package for Social Sciences), version 21XVIII, will be used to evaluate the data. The data analysis will employ the Two-way ANOVA test. When the p-value is less than 0.05, the results are considered statistically significant.

All steps of sample preparation will be performed by the principal investigator, under supervision. All calculations and measurements are done by computer software with no risk of personal bias, so no blinding is required.

Only descriptive values will be required. Statistical analysis is not applicable because there is no sample.

III. RESULTS

Finite Element Analysis was used to identify stresses in each model's nodes (FEA). Stress outlines were placed on the original model to show these findings. The models' computed numerical data for stress, deformation, and safety factors were used to create color visualizations. The numerical values for the stress, deformation, and safety factors are presented using color coding for the relevant situations.

For each model, the von Mises stress, maximum main stress, and directional deformation were measured using the two distinct frameworks, Cobalt-Chromium and PEEK. The formula for von Mises stress was (S1-S2)2+ (S2-S3)2+ (S3-S1)2= 2Se2. where Se, also known as the "von Mises Stress," is the equivalent stress and S1, S2, and S3 are the major stresses.

The measurement of the maximum principal stress (peri-implant bone) was made. Directional deformation: It is possible to compute the internal and outward deformations of the assembly's screws. In order to estimate screw loosening, it was utilized to measure the micro movements on the screws inside the abutment.

Maximum stresses and micro-motion upon the two models under axial loading

The VM stresses on the screw-retained prosthesis and the bone between the Cobalt Chromium (CoCr) and PEEK models were found to be nearly similar to one another under axial loading, PEEK recorded 15.918 Mpa, while CoCr recorded 16.344 Mpa. The Cobalt Chromium recorded higher VM stresses regarding the stresses directed to the framework 137.06 Mpa compared to 12.193 Mpa for the PEEK material. Very similar Von Misses stresses are directed to the underlying bone by both frameworks (PEEK =9.765 Mpa, CoCr=11.257 Mpa). The PEEK framework showed higher stresses transmitted to the underlying implants compared to the CoCr framework ;173.71 Mpa compared to 137.06 Mpa. Stresses regarding the directional deformation on bolts were similar for both frameworks. (Table 3)

Table (3): Displaying the Maximum Principal Stresses under Axial Loading on Bone, the Von Misses (VM) stresses on Screw Retained Prostheses and Implants, and the Directional Deformation of the Bolts for both the PEEK and the Cobalt Chromium Frameworks.

Case		Von Misses (VM) stresses on screw retained Prosthesis (Mpa)	Von Misses (VM) stresses on Framework (Mpa)	Maximum principal stresses on bone (Mpa)	VM Stresses implant (Mpa)	Directional deformation of bolts (microns)
Material of the framework	PEEK	15.918	12.193	9.765	173.71	4
	Cobalt Chromium	16.344	137.06	11.257	137.06	4

Maximum Stresses and micro-motion upon the two models under oblique loading

The VM stresses on the screw-retained prosthesis and the bone for PEEK model were slightly higher under oblique loading, PEEK recorded 64.793Mpa, while CoCr recorded 53.072 Mpa. The Cobalt Chromium recorded higher VM stresses regarding the stresses directed to the framework 182.64 Mpa compared to 18.858 Mpa for the PEEK material. Very similar Von Misses stresses directed to the underlying bone by both frameworks (Peek=32.879 Mpa, CoCr=30.756 Mpa).

The PEEK framework showed higher stresses transmitted to the underlying implants compared to the CoCr framework; 336.22 Mpa compared to 133.58 Mpa. Stresses regarding the directional deformation on bolts were slightly higher for the PEEK framework 5 Mpa, compared to 4 Mpa for the CoCr framework. The stress under oblique loading is much greater than under axial loading. (Table 4)

Table (4): Illustrating the direction of deformation of the bolts for both the PEEK and the Cobalt Chromium frameworks, as well as the Von Misses (VM) stresses on the screw-retained prosthesis and implants and the Maximum Principal Stresses under Oblique Loading on Bone.

Case		Von Misses (VM) stresses on screw retained Prosthesis (Mpa)	Von Misses (VM) stresses on Framework (Mpa)	Maximum principal stresses on bone (Mpa)	VM Stresses implant (Mpa)	Directional deformation of bolts (microns)
Material of the framework	PEEK	64.793	18.858	32.879	336.22	5
	Cobalt Chromium	53.072	182.64	30.756	133.58	4

In relation to the component or assembly, deformation was computed using the world coordinate system. Ux 2 + Uy 2 + Uz 2 equals U2. The three elements that comprise Deformation are Ux, Uy, and Uz.

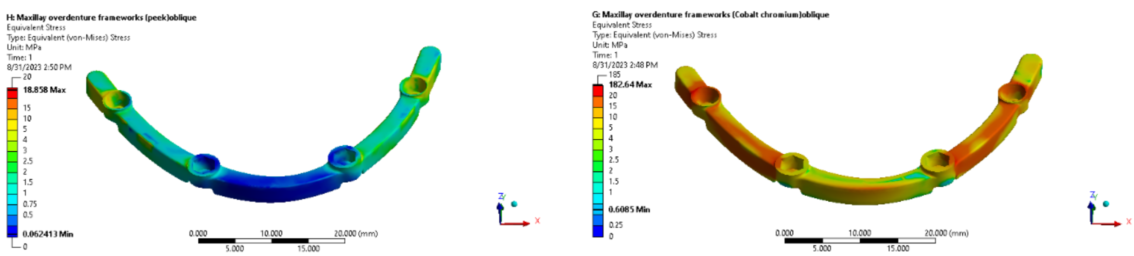
When the PEEK framework was subjected to axial loading the VM stresses recorded by the posterior implants were higher than that recorded by anterior implants, and very similarly the posterior multiunit abutment showed higher VM than the anterior Multi-unit abutments. (Table 5). The posterior multi-unit abutment showed higher VM stresses than the posterior implant for both right and left (120.71 for left multi-unit abutment, 31.638 for the left implant) (Table 5).

Under oblique loading the VM stresses recorded by the posterior implant and multi-unit abutment was greater than the anterior implant and multi-unit abutment (Table 5, Fig. 3). The VM stresses by the posterior multi-unit abutment showed higher VM stresses than the posterior implants (207.58 for left multi-unit, 82.193 for left implant) (Table5).

Table (5): Displaying the Von Misses stresses (Mpa) under axial and oblique loading for the left and right implants and multi-unit abutments as measured by the PEEK framework.

Loading	Position		Implant	Multi-unit-Abutment
Axial loading	Posterior	Right (R)	50.611	70.846
		Left (L)	c	120.71
	Anterior	Right (R)	7.093	8.076
		Left (L)	10.036	11.16
Oblique loading	Posterior	Right (R)	83.435	193.69
		Left (L)	82.193	207.58
	Anterior	Right (R)	26.864	33.471
		Left (L)	34.945	44.399

With respect to the Cobalt Chromium framework, Table (6) indicates that the anterior left implant had higher stresses (9.523 Mpa) than the right implant (6.753 Mpa). Under axial loading, the right abutment had more stresses than the left abutment (Table 5) but the anterior abutments showed lower strains. On the other hand, the posterior left implant (86.557 Mpa) registered higher stresses than the right implant (83.902 Mpa) when the Cobalt Chromium framework was loaded obliquely (Table 6). In contrast, the left abutment had greater stresses than the right abutment when it came to the posterior abutments. (Table 6).



(A) **(B)**

Figure (2): Shows maximum VM stresses on the framework under oblique loading A: PEEK framework, B: CoCr framework

Table (6): displays the Multi-unit-abutment and Von Misses stresses (Mpa) on the implants and the Cobalt-Chromium frameworks for the left and right implants under axial loading and oblique loading.

			Implant	Multi-unit-Abutment
Axial loading	Posterior	Right (R)	57.693	113.06
		Left (L)	31.999	112.75
	Anterior	Right (R)	6.753	10.974
		Left (L)	9.524	15.359
Oblique loading	Posterior	Right (R)	83.902	133.58
		Left (L)	86.557	111.99
	Anterior	Right (R)	28.829	49.232
		Left (L)	37.612	78.082

An analysis of the Von Misses stresses (Mpa) for the anterior and posterior implant and abutments, right (R) and Left (L), comparing the PEEK and Cobalt Chromium frameworks. The right and left implants displayed extremely similar Von Misses stresses under axial loading when comparing the Von Misses stresses between the Cobalt Chromium framework and the PEEK framework. The Von Misses stresses on the PEEK framework anteriorly (R=7.093 Mpa, L=10.036 Mpa) were marginally higher than those on the Cobalt Chromium framework (R=6.753 Mpa, L=9.524 Mpa) (Table 8). In contrast, both frameworks' posterior implant stresses were comparable (Table 7).

The right and left implants displayed very similar Von Misses stress under oblique loading between the PEEK and Cobalt Chromium frameworks. The Von Misses stresses on the PEEK framework posteriorly (R=83.435 Mpa, L=82.193 Mpa) were marginally higher than those on the Cobalt Chromium framework (R=83.902 Mpa, L=86.557 Mpa) (Table 8). While the pressures placed on the anterior implants of both frames were comparable (Table 7).

The stresses on the front and posterior abutments for the Cobalt Chromium framework and the PEEK are extremely close to one another in terms of the Von Misses stresses on the multi-unit abutments (Table 7,8).

Table (7): Under axial loading, the Von Misses stresses (Mpa) for the posterior and anterior implant and multi-unit abutments, right (R) and left (L), are located between the PEEK and the Cobalt Chromium framework.

Axial Loading		PEEK Framework	Cobalt Chromium Framework
Posterior implant	Right (R)	50.611	57.693
	Left (L)	31.638	31.999
Anterior implant	Right (R)	7.093	6.753
	Left (L)	10.036	9.524
Posterior Multi-unit abutment	Right (R)	70.846	113.06
	Left (L)	120.71	112.75
Anterior Multi-unit abutment	Right (R)	8.076	10.974
	Left (L)	11.16	15.359

Table (8): Under oblique loading, the Von Misses stresses (Mpa) for the anterior and posterior implant and multi-unit abutments, right (R) and left (L), are situated between the PEEK and the Cobalt Chromium frameworks.

Oblique Loading		PEEK Framework	Cobalt Chromium Framework
Posterior implant	Right (R)	83.435	83.902
	Left (L)	82.193	86.557
Anterior implant	Right (R)	26.864	28.829
	Left (L)	34.945	37.612
Posterior Multi-unit abutment	Right (R)	193.69	133.58
	Left (L)	207.58	111.99
Anterior Multi-unit abutment	Right (R)	33.471	49.232
	Left (L)	44.399	78.082

IV. DISCUSSION

The stress and strain analysis would be significantly affected by the material properties of implant fixtures, abutments, and restorations. These characteristics would be modeled by FEA as orthotropic, transversely isotropic, which is anisotropic, and isotropic. For a FEA to produce results that are clinically applicable, interface, loading conditions, and material properties need to be taken into account because they have an impact on accuracy. As a result, it was assumed that the properties of the material were homogeneous, linear, and isotropic (Ozcelik et al. 2011; Huang et al. 2008).

One of the most important FEA considerations is the bone to implant interface (Papavasiliou et al. 1997). Different contact algorithms are available in FEA Software, and they can simulate various real-world bone to implant contact types. The bonded contact type, which is the no separation contact type, and frictionless contact type are useful for describing the implant bone interface (Chou et al. 2008).

For the All-on-4 technique, a 45° angulation for distal implants is only advantageous if the cantilever length will be decreased. The optimum options to be considered are 17° or 30° angulations. Additionally, stronger framework materials dispersed more stress throughout their construction, which reduced the amount of stress on prosthetic screws (Taruna et al. 2014).

The advantage of guided-implant procedure in combination with the All-on-4 technique has improved accuracy and resulted in better precision of implant placement simplified procedure for the technician, prosthetic-driven planning, and placement. help the clinician in avoiding damage to anatomical structures. Guarantees the exact implant placement in the available bone. predictability improvement, allows placement of longer implants using cortical bone anchorage on account of the angulations of the implants, anteroposterior (AP) spread of the implants assist in restoring teeth up to the first molar, Surgical guide of full edentulous cases is best method to place implants parallel (Trobough et al. 2018; Vaithilingam et al. 2022; Afshari et al. 2022).

On the other hand, the cases of maxillary bone atrophy, the risk of implant positioning error is increased; the actual implant position at the end of the surgical process differs from the virtual plan, positioning issues with the surgical template over CBCT. Remaining teeth could make implant placement difficult to plan for, difficult to adjust for not sufficient mouth opening, and have an irregular or thinner bone crest (Schneider et al. 2009; Vinci et al. 2020; Cattoni et al. 2021).

The FEA models would be limited in the current research due to the mechanical behavior of the bone, which was expected to be homogenous, isotropic, and elastically linear. To depict a successful osseointegration, the FEA model used assumed complete rigidity of 100% bone toward implant contact. In order to prevent any stresses that could shorten the prosthesis' lifespan, it was also assumed that all the parts were going to remain completely passive for the other.

The results of this study calculated stresses that the axial and oblique load are higher in PEEK than cobalt chromium, which may be attributed to the fact that the higher modulus of elasticity of cobalt chromium results in increased rigidity and reduced flexibility compared to PEEK. This leads to uniform stress concentrations and uniform load distribution in the cobalt chromium framework. The von Mises (VM) stress is a mixture of normal and shear pressures that occur in all directions. This stress is important in examining the response of different materials and evaluating the damaging effects to underlying structures (Abu Hasan et al. 2017).

When contrasting the anterior and posterior implants' Von Misses stresses using both frameworks, the posterior implants that were installed at the 17-degree angle showed slightly greater stresses than the anterior implants, that comes in agreement with several authors who have reported that there is a connection between implant inclination and stress values (Canay et al. 1996; Federick et al. 1996).

Also, the results of this study reported, there was no change in terms of extreme von Mises stresses when comparing a maxillary all on four configurations with posterior implants installed at 15 degree and 30 degrees while when posterior implants were installed at 45 degree it resulted in increased stress standards at the bone–implant border. As the tilting of an implant increases this would increase the stresses directed towards the implant. Sannino et al. 2015 concluded that loading and tilting of distal implants will increase the peri-implant bone stresses.

Furthermore, in both posterior and anterior locations, it was consistently observed that the maximum stress values were found distally when implants were tilted. This indicates that the left (L) side of the posterior implants exhibited higher stresses compared to the right side. Under oblique loading conditions, both the PEEK framework model and the Cobalt Chromium framework model demonstrated similar stress distribution patterns.

In this study, tilting implants splinted with a framework would be a reliable treatment option that would decrease the cantilever length to achieve better load distribution. The distribution of the implants in the prosthesis will decrease implant bending because (Bellini et al. 2009), the implants are splinted with a framework with implant supported restoration (Daellenbach et al. 1996) and would allow for better stress distribution, that would explain the reason that the VM stresses directed on the multiunit abutments were same on the posterior and anterior implants.

However, when comparing the stress values, both frameworks exhibited greater stresses under oblique loading compared to axial loading. This discrepancy likely arises from the altered force distribution and angulation, placing more strain on the frameworks and implants.

Studies have shown that the framework material affects the pressures placed on all prosthetic components and bone tissues (Zincir et al. 2021), while no discernible effect was reported in another study (Tribst et al. 2020).

In this study, the failure theory of principal stress was applied to analyze and compare the maximum and lowest principal stresses for bone tissues with their corresponding tensile and compressive strengths (Fischer and Stenberg, 2013). The permitted tensile and compressive limits were taken into consideration for cortical bone with normal density, taking into account a safety factor of 1.5. Spongy bone exhibited similar trends in allowable tensile and compressive limits across both groups, consistent with peri-implant bone characteristics.

Under axial loading, Cobalt Chromium showed higher maximum principal stress than PEEK. Conversely, under oblique loading, PEEK displayed higher maximum principal stress than Cobalt Chromium, indicating varying stress distributions depending on loading conditions.

Using multi-unit abutments, a framework is fastened to titanium implants in the "All-on-4" technique. This optimizes load distribution and provides support, minimizing the amount of stress placed on the mucosa and bone structures. Acrylic resin-securing acrylic artificial teeth are supported by this structure (Patzelt et al. 2014). Proper selection of the superstructure material is crucial in fixed prostheses to ensure sustained clinical success, as it distributes loads to substructures, including bone tissue (Cattoni et al. 2021).

The right and left implants showed comparable Von Mises stresses when comparing implants across PEEK and Cobalt Chromium frameworks. Under axial loading, stresses on the PEEK framework were comparable to those on the Cobalt Chromium framework. However, stresses on the multi-unit abutment were slightly higher in PEEK framework, particularly in the left-loaded abutment, compared to Cobalt Chromium framework.

V. CONCLUSION

PEEK and Cobalt Chromium frameworks used in an all four concept of the edentulous maxilla have resulted in significantly superior behavior of PEEK over CoCr in the framework, PEEK frameworks outperform Cobalt-Chromium in All-on-4 applications, PEEK frameworks distribute stress evenly, lessening strain on prosthetic screws and underlying bone. PEEK's pliability ensures uniform load transmission, mitigating the likelihood of component failure or bone resorption. Superstructure and peri-implant stresses directed to the surrounding implant and multi-unit abutments used. While showed minimal behavior on the implant and the abutments themselves. Posterior implants installed at 17 degrees showed higher Von Mises stress compared to the anterior implants when using the PEEK and Cobalt Chromium frameworks.

Author's Contribution

Ridhab Muhib Aldeen wrote the manuscript and was responsible for data collection and entry. Mohamed A. Nada supervised the project. Mohamed Farouk Abdallah and Mai Adel Helmy were responsible for data curation and Implementation. All authors reviewed the final draft and approved it.

Conflict of Interest

No conflicts of interest exist. We attest that each of the identified writers has read and accepted the work, and that we have all authorized the authors' specified order.

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Ethical Approval

This study protocol was approved by the ethical committee of the faculty of dentistry- at Cairo University on: 29/11/2022, approval number: 15 11 22. Permission was obtained from Cairo's educational hospitals and institutions to access the database used for this study.

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