ComparsionBetween All Zicronia, All PEEK and Zirconia-Peek Telescopic Attachments for Two Implants Retained Mandibular Complete Overdentures. In-Vitro Stress Analysis Study

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Abstract:

Purpose: This in-vitro study was performed to evaluated stresses applied to the implants retaining mandibular complete overdenture with three different resilient telescopic attachments.

Materials and methods: Three identical clear acrylic resin models of completely edentulous mandibular arch were selected for this study. One implant was installed in each canine region of the models by using guide template. The models were scanned to design telescopic attachment using CAD/CAM technology on model 3D virtual image. According to the material of fabrication of the resilient telescopic attachment, the models were categorized as follows: **(All Zirconia telescopic group zz) :**The primary and secondary telescopic crown were made from ZrO_2 . **(All Peek telescopic group pp):** The primary and secondary were made from PEEK. **(Zirconia Peek telescopic group zp):** The primary was made from ZrO_2 and secondary telescopic was made from PEEK. Three identical mndibular complete overdentures were constructed. The secondary telescopic crowns of each group were picked up within the intaglio surface of each overdenture. Four strain gauges were installed on the buccal, lingual, mesial and distal side parallelfor each implant. A unilateral and bilateral load of 70N was applied. The loading protocol was repeated five times for each loading application.

Results: In bilateral loading the highest stresses were recorded with PP, followed by ZZ and the lowest stresses were noted with ZP for mesial and buccal sites, while in unilateral loading the highest stresses were recorded with PP, followed by ZZ and the lowest stresses was noted with ZP for all sites.

Conclusion: Within limitation of this in vitro study Zirconia Peek resilient telescopic attachment was promised for reduce stress around implants mandibular overdenture.

Key word: Overdenture, Implants, Resilient telescopic attachment, stress analysis.

Introduction

Use of implant supported overdenture has improved outcomes for edentulous patients compared with conventional denture. These include, reduced residual ridge resorption, improved retention and support of the prostheses resulting in better quality of life, function, chewing nutritional status and general health.(1)

Telescopic crowns were initially introduced as retainers for dental prostheses. They are also known as a double crowns, crown and sleeve coping (CSC).These crowns consist of inner or primary telescopic coping, permanently cemented to an abutment and congruent detachable outer or secondary telescopic crown, rigidly connected to a detachable prosthesis. The secondary crown engages the primary coping to form a telescopic unit and serves as an anchor for the remainder of the dentition. Telescopic attachment provided support, retention and prosthesis can be repaired without reconstruction of the entire superstructure, despite a localized failure. The patient can disengage telescopic restoration with dislodgment of the outer telescopic crowns from their coping. (2)

In prosthetic dentistry, metal alloys are most commonly approved materials,due to their excellent physico-mechanical properties, but some drawbacks like biocompatibility might be problematic, especially in combination with other metals in oral cavity.The direct contact of different metals in oral cavity, as well as metallic ions solved in saliva may cause galvanic corrosion.(3)

Useing ceramic materials for the fabrication of double-crown attachments were first described in 2000. (4) Zirconia (ZrO_2) is a ceramic material used for medical device, displays good esthetics appearance, high mechanical strength, high biocompatibility, and resistance to wear has promoted its usage in recent years. The use of tooth-colored ceramic materials also is stated to have appositive psychological effect on patients and promotes improvements in oral hygiene. (5)

Polyetheretherketone (PEEK) represents a modification of the main thermoplastic high-performance polymer group Polyetherarylketone (PEAK). It is a high-temperature thermoplastic polymer, consisting of an aromatic backbone molecular chain, interconnected by ketone and ether function group. (6) PEEK as well as ZrO_2 represent both very biocompatible materials and are used for several applications e.g. for dental implants, provisional abutments, and fixed dental prostheses (FDP). (3)

Recent publication reported that PEEK is a suitable material for double crown system. (7) A new concept could be the combination of these two biocompatible materials e.g. ZrO2 and PEEK in order to produce metal–free dental prosthesis and telescopic crowns.(3) Consequently, the aim of this study was to evaluate stresses transmitted to dental implant in case of using different tooth-colored materials for telescopic attachment fabrication.

Materials and methods:

1-Fabrication of clear acrylic resin model: Complete mandibular edentulous stone cast for adult edentulous patient was selected for this study and three identical clear acrylic resin modelswere duplicated.

2-Simulation of oral mucosa: Residual ridge and retro molar pad area of clear acrylic resin model were covered by base plate wax with 2mm thickness. A plaster index was created over the model and extended to buccal and lingual area of the model, after the plaster index was set, the wax was removed. The internal surface of index was filled with auto-polymerized silicon material, and then, the index was repositioned on the model with firm holding by rubber band till complete polymerization of silicone soft liner coating.

3-Fabrication of Implant placement guide template: Implant placement guide templatewas fabricated from clear acrylic resin with two guide holes in canine region.

4-Installation of implants in clear acrylic resin models: Dental milling machinewas used to drill two vertical holes through the guide template in canines region bilaterally.

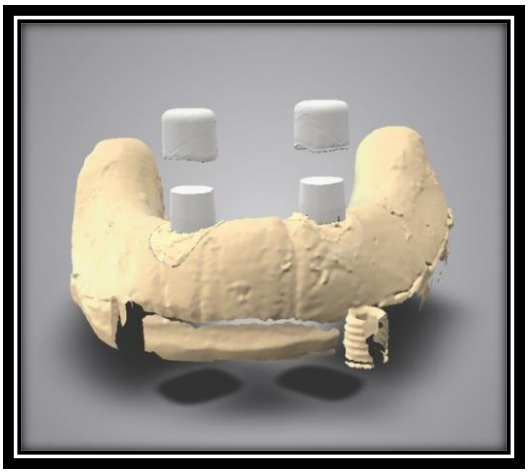
5-Study group: According to the material of fabrication of the resilient telescopic attachment, the models were categorized as follows: **(All Zirconia telescopic group zz) :**The primary and secondary telescopic crown were made from ZrO_2 . **(All Peek telescopic group pp):** The primary and secondary were made from PEEK. **(Zirconia Peek telescopic group zp):** The primary was made from ZrO_2 and secondary telescopic was made from PEEK. The models were scanned to design resilient telescopic attachment using CAD/CAM technology on model 3D virtual image.**Fig 1**

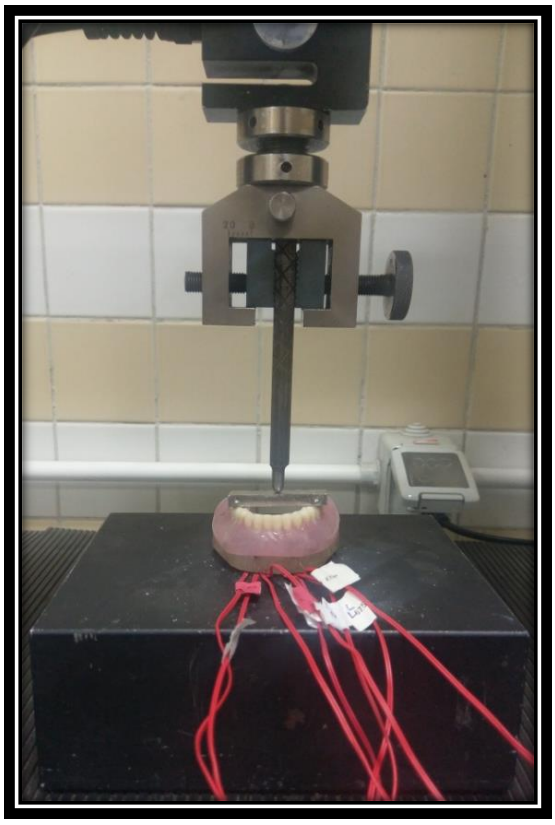
6-Fabrication of acrylic resin mandibular overdentures: Three identical mndibular complete overdentures were constructed. The secondary telescopic crowns of each group were picked up within the intaglio surface of each denture.

8-Installation of strain guages: Four strain gauges were installed on the buccal, lingual, mesial and distal sides parallelfor each implant.

9-Universal testing machine (UTM):A unilateral and bilat

eral load of 70N was applied. The loading protocol was repeated five times for each loading application.**Fig 2**





Bilateral loading

Results:

Table 2.Comparison of median values of stresses between groups during bilateral loading.

	PP Group			ZP Group			ZZ Group			Test of significance (Kruskal Wallis test)
	med	min	max	med	min	max	med	min	max	
Mesial	338	312	364	39	26	52	208	169	221	P=.002
Distal	806	767	845	130	117	143	689	650	715	P=.003
Buccal	611	585	637	208	188	228	468	442	481	P=.002
Lingual	559	533	585	78	65	91	481	455	520	P=.002

Table2 . Comparison of median values of stresses between groups during unilateral loading on the right implant (loading side)

	PP Group			ZP Group			ZZ Group			Test of significance (Kruskal Wallis test)
	med	min	Max	med	min	max	med	min	max	
Mesial	247	234	260	65	39	78	117	104	130	P=.002
Distal	494	481	507	26	13	39	91	78	104	P=.003
Buccal	286	273	299	13	10	16	208	195	221	P=.002
Lingual	723	671	749	26	13	39	684	658	710	P=.005

Discussion:

For canine implants during bilateral and unilateral loading, **PP** telescopic resilient attachment recorded the highest stress value than other group, this may be due to the elastic modulus ranges between 3 and 4 GPa of peek martials. These observations coincided with other study in which PEEK telescopic retained prosthesis resulted in statistically significant higher strain in most of the channels when compared to Co-Cr alloy one. This could be attributed to the much higher Young's modulus of Co-Cr alloy (220-230 GPa) [8] compared to that of the PEEK (3–4 GPa).[9] the more rigid the connection for the retainer the less stress would be to the denture mobility and vice versa.

In this study, during unilateral loading side in ZZ group the highest stress value in lingual side followed by distal, buccal and mesial.in the other hand in non-loading side the highest value was recorded in buccal side followed by distal ,mesial and distal side this may be due to ZrO2, a ceramic material displays a high mechanical strength compared to traditional metals this properties of rigidity gives the higher stress than ZP .this outcome in agreement with ***Hofmann et al,***[10] pointed out that the resilient telescopic attachments compensate for soft-tissue resiliency, therefore less stresses transmitted to the implant surface when compared to rigid type of telescopic crown. Additionally, a tiny amount of circumferential play between primary and secondary coping

minimizes the moment loading of the implant during chewing.

In other hand ZP group when compared with the other group during unilateral loading was recorded the lowest stresses value than PP and ZZ for the all four directions (mesial/distal and buccal/lingual), while in bilateral loading was recorded the lowest stresses value in mesial and buccal sites than distal and lingual sites. this may be due PEEK has a modulus of elasticity (E-modulus 4 GPa) great overdenture implants compared to other conventional materials such as titanium (E-module 110 GPa) or zirconium dioxide (E-modulus 210 GPa). In addition, it had a Vickers hardness of approximately 400 MPa and a bending capacity of 314 MPa. Conversely, zirconia is three times harder (1200 HV) and its resistance to bending is 1400 Mpa.(11) It's the capacity of load absorption has led some authors to recommend its use in patients with severe bruxism.(12) Finite element analysis suggests that maximum contact pressure at the bone-titanium implant interface can be significantly reduced by using a PEEK crown rather than a ceramic crown.(13) At the same time as providing optimal elasticity which resembles the natural structure of the hard tissue.in other studies were concluded that PEEK a suitable material for removable prosthesis when using as secondary crown over the primary crown as fabricated from zirconia crown lead to a strong wedging due to the flexibility of PEEK and the differences in elastic modulus.

In ZZ group loading side recorded the higher stresses than non-loading side at lingual and mesial sites respectively. Non-loading side recorded significant higher stresses than loading side at buccal and distal sites respectively. During unilateral loading lingual loading recorded the highest stress, and the lingual non-loading recorded the lowest strain at canine implants. This may be due to movement of the canine implants lingually upon load application on first molar area because the load was applied on the central fossa of first molar which is located lingual to the position of canine implants. Therefore, more compression of acrylic resin around the lingual side of the canine implants occurs. Similarly ***Takahashi et al,***(14) observed that anterior implants supporting maxillary overdentures are strained distally and palatally.

In this study the unilateral loading gives the highest stress value than bilateral loading in PP and ZZ groups, during unilateral loading lingual loading recorded the highest stress, and the lingual non-loading recorded the lowest strain at canine implants. This may be due to movement of the canine implants lingually upon load application on first molar area because the load was applied on the central fossa of first molar which is located lingual to the position of canine implants. Therefore, more compression of acrylic resin around the lingual side of the canine implants occurs. Similarly ***Takahashi et al,***(14) observed that anterior implants supporting maxillary overdentures are strained distally and palatally

While the ZP bilateral loading gives the highest stress value than unilateral loading, this may be due to settling of the denture base posteriorly up on load application on first molar area; therefore the denture rotates around the canine implants. This rotation is prevented by the parallel walled telescopic attachments, thus more load is transmitted to the canine implants by the cantilever action of the denture base. In line with this explanation, ***Misch,*** (15) founded that RTA at canine implants prevent rotation of the overdenture around linear fulcrum line.

The results of this study are only descriptive because the physical properties of acrylic resins do not simulate the complex nature of living bone regarding mechano-biology and osseointegration.(16) In the current study, the effect of axial load application was evaluated. The absence of nonaxial loading is a limitation of this study because the direction of the load can change the patterns of tension. Further studies may be helpful to evaluate the load transfer characteristics with different load directions applied to vertically oriented and inclined implants.(17)

Conclusion:

Within limitation of this in vitro study Zirconia Peek resilient telescopic attachment was promised for reduce stress around implants mandibular overdenture

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