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Retention of Non-Metal Single Crown Coping Supporting Single Implant Mandibular Overdenture (In –Vitro Study)

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ABSTRACT

Purpose: This study aimed to evaluate the retention of single implant mandibular overdenture using different single crown coping materials. **Materials and Methods**: Clear acrylic resin mandibular cast was fabricated with single implant located in the mid-line of the cast. The cast with the implant was scanned for designing of nine copings of different materials using computer aided design computer aided manufacture CAD/CAM and according to material used for copings fabrication, models were categorized as follow: Poly etherether ketone (PEEK) group, Zirconium dioxide (ZrO2) group, hybrid composite resin coping group. Nine identical mandibular complete overdentures were constructed, tensile force for removing overdenture with copings was then recorded. **Results:** Comparison of recorded tensile strength results showed a significant difference among groups where the highest retention was recorded with Zirconia group, followed by PEEK and the lowest retention results were noted with Hybrid composite resin. **Conclusion:** Within the limitation of this in vitro study, it could be concluded that single crown that fabricated from ZrO2 for supporting implant supported overdenture showed better retention results in comparison to PEEK a hybrid composite one.

KEYWORDS

Polyetheretherketone copings,
Hybrid composite,
Implant-overdenture

INTRODUCTION

Overdenture is a removable partial or complete denture that covers and rests on one or more remaining natural teeth, roots, and/or dental implants; a dental prosthesis that covers and is partially supported by natural teeth, tooth roots, and/or dental implants. It is also called as overlay denture, overlay prosthesis, and superimposed prosthesis [(1)].

Overdentures have been recoganizded for their superior advantages in terms of retain the level of alveolar bone, preserving of proprioceptive response, improved stability, increased patient satisfaction (as patient is pleased to preserve some of his own teeth) and over all simple steps of fabrication [(2)].

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Researches are currently more concerned with being more conservative and preservation of natural structures by using only one implant to support mandibular overdenture[3].

Single implants have been shown to have the same biomechanical effect as two implants supporting overdenture against lateral forces to denture base and abutment movement moreover it is more conservative especially in the elderly [4].

Computer-aided design/computer-assisted manufacturing (CAD/CAM) is a growing technology for dealing with various materials such as zirconia or titanium. In addition, highly detailed designs can be developed that require passive seating [5].

Zirconium dioxide (ZrO2), generally referred to as Zirconia, was discovered in early 1800 by German chemist. However, it has not been used in dentistry since a few decades. Zirconia is the material of choice in dental applications due to its superior properties. The phenomenon of zirconia toughened transformation results in extremely bending and resistance of tensile strength, high compact strength, and even fracture and chemical resistance. It has been used with the introduction of zirconia as a self-repairing to avoid crack propagation [6]. Studies reported that the processing of zirconium is becoming very popular because of its high esthetic properties and biocompatibility, in addition to its low plaque sensitivity, its high mechanical resistances compared with conventional metals make it a material of choice [7,8].

Polyetheretherketone (PEEK) is a thermoplastic resin that has been for many years used dentistry and medicine, offering a special combination of mechanical and physical properties due to its unique structure. It contains about 20 percent of its filler form, providing an approximately 4 GPa (grade point average) elastomeric module that reduces stress causing tension and reduces stress. PEEK can be processed by two techniques, Milling by computer aided design/computer aided manufacturing (CAD/CAM) from blanks or vacuum pressing. In prosthetic dentistry, PEEK has been used in removable prosthesis, bridges, or crowns with high long term of survival rates and improved patient comfort [9,10].

For CAD/CAM (computer aided design and computer aided manufacturing) technique new materials, namely resin-ceramic hybrid materials have been produced. These materials combine the advantages of ceramics such as toughness and color consistency with synthetic resin, such as better bending and low abrasion. To reduce the perio-overdenture costs composite coping was developed. It has more advantages such as simple processing, better re-intervention possibilities, easy to repair, attachment replacement, and endodontic re-treatments. [11]

This purpose of this in-vitro study was to compare different crown materials as coping (telescopic attachment) in relation to retention of implant supported overdenture. The hypothesis was that changes in the coping material influenced the retention of the supported overdenture. The null hypothesis is that no difference will occur between groups.

MATERIALS AND METHODS

Sample size calculation

Was performed using G* Power version 3.1.9.2 (Faul, 2007) the effect size was 0.433 using alpha level of 0.05 and beta level of 0.05, ie. Power= 98 % the estimated minimum sample size (n) was a total of 9, 3 for each group

Fabrication of the model cast

Clear resin cast was created from an standardized completely edentulous mandibular mold, an implant was installed in the middle of the mandibular ridge (Ø 3.30-L 10, Frontier dental implant, Spain). Fig. (1)

Abutment was connected to the implant fixture, after attaching of the cast to the table of milling machine (Nouvag AG Frasgerat AF30 Milling Machine Unit Precision Dental Tool) reduction is done. Fig 2(A, B&C)

Fabrication of copings

Implant abutment were ground polished and, sintered and served as primary telescopes with a minimum thickness 6 mm., Fig. 3 (A&B), Cast with the implant and abutment was scanned using (Scanner medit i500), secondary copings were designed with 1.0 mm thickness to cover primary copings the 3D scanned data from digital scanning were saved in a standard tessellation language file (STL). Virtual coping was designed as cylinder parallel walled with 6-degree occlusal convergence by subtracting the scanned implant abutment from the scanned cast. Fig (4). Nine copings (3 for each group) were fabricated through milling machine (Arum 400x). Fig5 (A&B).

Group a: (Peak, Vasden Bioceramics Co., Ltd)

Group b: (Zirconia Nacera pearl, Italy)

Group c: (Hybrid composite Nacera hybrid blocks, Italy)

Construction of the overdentures

Nine identical overdentures were fabricated by conventional lost wax technique, over the clear resin cast using heat cure acrylic resin (heat cure acrylic resin, Acroston Ltd, Egypt), three dentures for each group.

Picking up was used for picking of the secondary copings in the fitting surface of the denture and fixed in their place using cold cure acrylic resin (cold cure acrylic resin, Acrostone Ltd, Egypt), excess was removed, and finishing is carried out. Fig. 6 (A&B)

Figure (1): Ø 3.30-L 10, Frontier dental implant, Spain.

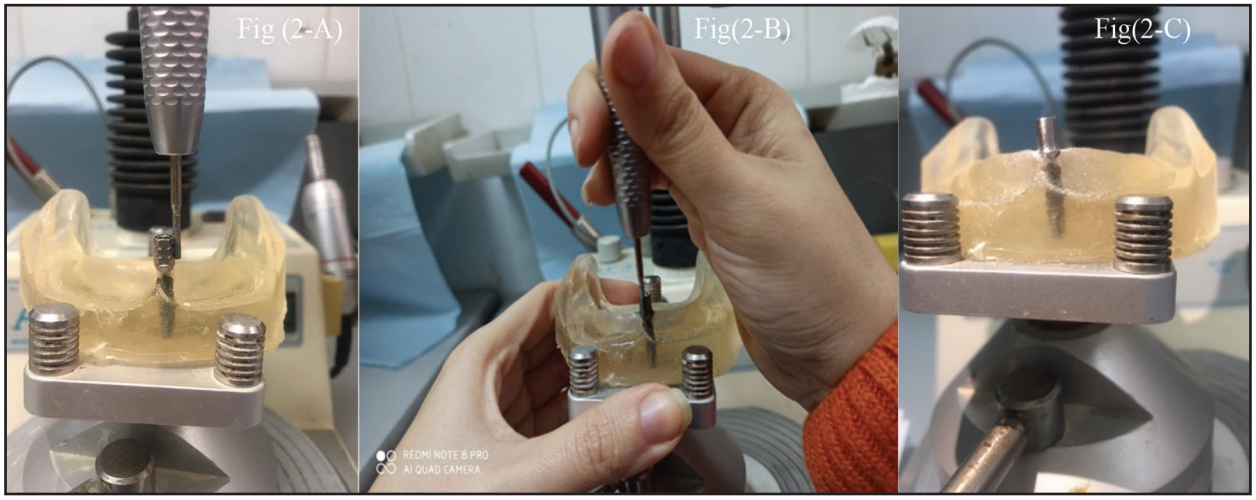

Figure (2) **A)** The cast is attached to the table of milling machine , **B)** Reduction is carried out with minimum thickness 6mm reduction is carried out, **C)** Finished abutment reduction

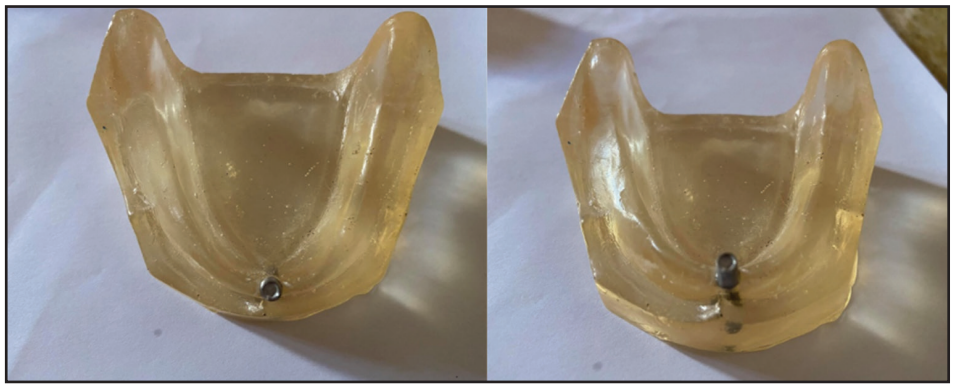

Figure (3) **A)** Top view of reduced abutment as telescopic crowns, **B)** Implant abutment polished and sintered as telescopic crowns

Figure (4) Designing of the crown after scanning of the implant abutment

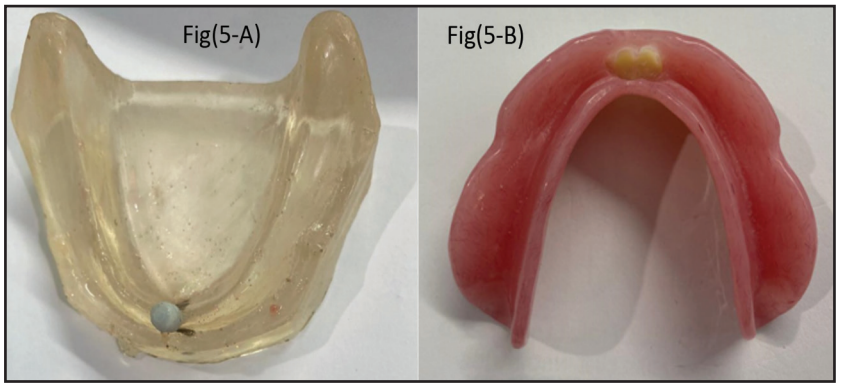

Figure (5) **A)** Secondary coping is applied on implant with telescopic crown, **B)** Denture prepared for picking up of the 2nd coping

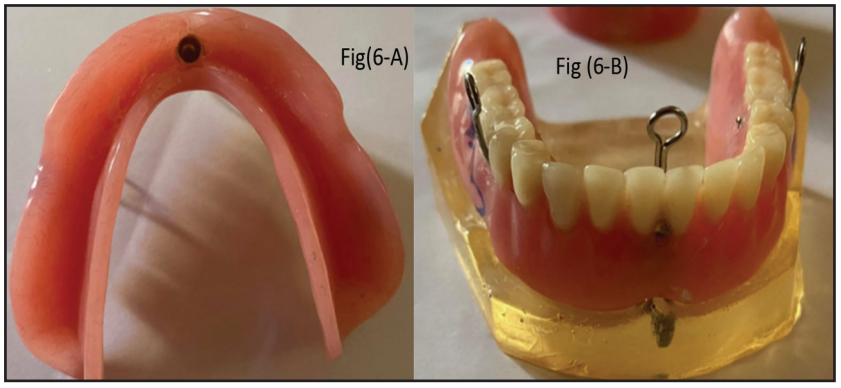

Figure 6) **A)** 2nd coping is picked-up in the lower overdenture, **B)** over denture is attached to implant in the silicon cast and wire loops attached for retention measurements.

Measuring of retention:

Each denture was attached by a single metal chain from three points (between 2nd premolar and 1st molar on each side and between two centrals) the three metal chains are were collected in one metal ring at the top.

Each cast was inserted in (Instron 5567 compression tension tensile meter), each of the models were subjected to 5 pulls each to dislodge the overdenture from the acrylic model, and the force values as indicated on the digital indicator were tabulated (Table 1). The dislodging force was applied in a vertical direction in the center of the acrylic block joining the three metallic chains holding the overdenture. Fig.7 (A&B)

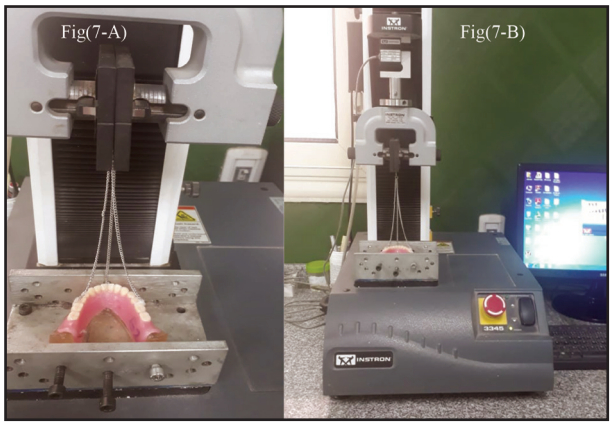

Figure (7) **A):** Metal chain are attached to three point of the overdenture and placed in the Universal testing machine, **B):** Tensile loading is applied to the overdenture

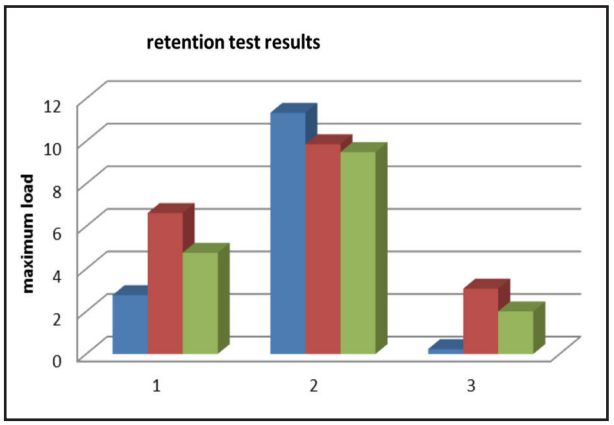

Figure (8): A bar chart diagram showing the difference in results obtained from retention measurements of the three groups

RESULTS

The mean values for denture/copings retention test for all dentures of the three studied groups were recorded and statistically analyzed.

Data were presented as means and standard deviation. Comparison of the repeated measures was performed using. ANOVA test showing a statistically significant difference. There was a significant difference in retention values (N) between observation groups (P<.001).

Table (1): *Mean and standard deviation of tensile forces applied on the three tested groups*

Results of applied forces on different groups				
	Group (A)	**Group (B)**	**Group (C)**	
Mean	2.7644	11.33	0.23114	**P-value**
	6.6208	9.8536	3.0666	
	4.7538	9.483	2.002	
Standard deviation	1.323556	1.901388	0.056247	
	0.623635	0.916273	0.386841	
	0.774987	0.386841	0.835797	0.00545

The results reveal that, group (b) zirconia showed the high mean value of retention, while the least means values of retention was noticed in group (c) hybrid composite.

These values were statistically highly significant between tested groups for three items of investigations at $p \leq 0.01$.

DISCUSSION

Tooth supported removable overdenture with telescopic copings attachment provides better retention, stability, support, stable occlusion and better proprioceptive reflections enabling better control of mandibular movements that enhance chewing efficiency and phonetics[12].

Different CAD/CAM materials act very differently when placed in function opposing different materials which accepted by the results from this study showed higher retention result with using of copings made from Zirconia for supporting single implant mandibular overdenture than copings made from PEEK or Hybrid composite material [13].

Results obtained from this research supported by studies showed that the use of ceramics in dentistry, among other materials, zirconia was preferred to be used for manufacturing frameworks due to its mechanical and biocompatible properties [14].

Several studies have recorded that fabrication of zirconia copings provides retention of a telescopic crown-retained over-denture and positive mechanical properties of zirconia copings in fixed restorations [15,16].

Current studies proved that retention behavior of zirconia is adequate and consistent. Because of the beneficial properties of zirconia and the efficient CAD/CAM-based development, this innovative form of attachment is appealing [17].

Research stated that Zirconium dioxide present in high elastic modulus and are rigid and stable, whereas PEEK is soft and ductile [18]. While PEEK's other excellent properties such as biocompatibility, reduced cost, easy fabrication but have been known to be softer material than metal this can explain reduced retention compared to Zirconia and Hybrid composite copings [17].

The findings of this study agree with results of another study comparing zirconia, PEEK and composite blanks copings which suggested that in the metal-free copings tested, zirconia showed the best adaptation. Copings retention was not affected by internal fit or material type [19].

This result was explained by the disparity in the physical properties of the two materials in which PEEK has a low modulus of elasticity (4 GPa) compared to zirconia (210 GPa), thus PEEK restorations absorb occlusal loads and experience wear [1].

Hybrid composite copings not well known as single copings for supported overdenture, in this study it showed the least results in retention force testing in relation to the other copings materials. While composite is known for its ease of manipulation, low cost and good esthetics, farther studies is indicated hybrid composite as copings if used as single crown, it requires more means for retention although it may display improved retention in telescopic crowns [11].

CONCLUSION

Within the limitation of this in vitro study, the following could be concluded:

Single crown fabrication from ZrO2 for supporting implant supported mandibular overdenture showed better retention in comparison to PEEK and hybrid composite ones.

RECOMMENDATION

This research was an invitro study, further investigations should be performed to be applied in vivo.

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