JODR

Volume 10, Issue 2, 2023

Fracture Resistance of Vita Enamic® Crown Retained Mono-Implant with Two-Cement Interface

[1]Shahad Mohammed Shakir BSc, [2]Saja Ali Muhsin, PhD and [3]Raad Al Marza, PhD
[1, 2] Middle Technical University, College of Health and Medical Techniques, Baghdad, Iraq. [3]The University of Sheffield, School of Clinical Dentistry, Sheffield, UK.
Corresponding author: Saja Ali Muhsin
E. mail: dr.sajaali79@gmail.com

Received 12 December 2022.
Accepted for publication on February 25, 2023.
Published April 27, 2023.
Doi: https://doi.org/10.58827/308487mcqkat

Abstract
Background The selection of implant-restorative components and mechanisms must be considered a critical factor for the long-term success of implant-supported prosthetics. To date, regarding mono-implant-supported single crowns, there is inadequate systematic data to support a single connecting system, and the decision remains controversial. **Objectives** In vitro current study aimed to compare the effect of two cement interface spaces of cement-retained mono-implant on the fracture load of the hybrid crown. **Material and Methods** Fourteen mono-implant abutments were attached and embedded in acrylic resin blocks. They were divided into two groups according to cement interface space of 80µm and 160µm (n=7). The full anatomical crown was milled using Vita Enamic® with a uniform cement space of 80µm and 160µm by Computer-aided design and computer-aided manufacturing (CAD/CAM) production method. The study data were statistically analyzed using the Student's t-test, with a confidence interval of 95%. **Results** A statistically significant difference was noticed between the two groups ($P \leq 0.05$). In a cement space gap of 80µm, the mean fracture load value was 2179(±97)N. However, a mean value of 1814(±102)N was recorded in a cement space of 160µm. A significant increase was found in the hybrid crown with 80µm cement space. **Conclusion** Within the scope of this in vitro investigation, a stronger mono-implant hybrid crown was noticed with a cement space of 80µm than that of 160µm.

Keywords: Fracture resistance; mono-implant; cement; vita enamic®

Introduction

The computer -aided -design /computer -aided manufacture (CAD/CAM) production method exhibited a significant improvement and development approach by using high-esthetic materials for restorative dentistry (Papadopoulos et al, 2020; Sadid-Zadeh, 2023; Queiroz et al, 2023; Elassy et al, 2023). Several ceramic systems for crown production using the CAD/CAM method have been introduced and developed by using different materials and methodologies (Ateş, 2022; Ellakany et al, 2023). Metal-free all-ceramic fixed restoration such as hybrid dental ceramics are becoming more popular due to their superior properties such as esthetic (Takano et al, 2023), mechanical (Atalay and Öztaş, 2022; Bonyatpour et al, 2023) and biocompatible (Duplantis, 2021;

Elassy et al, 2023). Vita Enamic is an example of such representative material that consists of a 3D network of fine glass ceramic infiltrated with a combination of urethane dimethacrylate (UDMA), and triethylene glycol dimethacrylate monomers (TEGDMA) (Mainjot et al, 2016; Silva et al, 2023). This composition has ceramic-like fine surface structure characteristics and reduced brittleness. Furthermore, it provides a higher fracture resistance which is advantageous in opposition to loading forces and improves the restoration milling process (Adolfi et al, 2020; Rohr et al, 2021). Such a material, in particular, may be increasingly used for crown restorations supported by implants (Naumann et al, 2023). It is most appropriate for prosthetic restorations on implant abutments as an alternative to core-based and zirconia-based crowns with ceramic veneers, as they have a potential effect on the chipping due to the processing methods (Külünk et al, 2017; Ellakany et al, 2023). Yet, to further increase the benefits of monolithic all-ceramics, hybrid ceramics were designed using CAD/CAM (Edelhoff et al, 2019; Yadav et al, 2023; Miura et al, 2022). Furthermore, it may be possible to efficiently replacement of a missing tooth on an implant abutment (Tribst et al, 2020; Sadid-Zadeh, 2023). Cement-retained implant restorations have significant advantages in terms of esthetics, passive crown adjustment, laboratory methods, and the potential for enhanced load distribution during function (Lopes et al, 2019). Cemented prostheses are also used to address poor implant position and to improve occlusion control (de Melo Moreno et al, 2022). The use of dental cement for implant-supported restorations seems to improve the passiveness of the prosthesis by filling the gap between the abutment and the design of the restoration (Li Chin and Han Shiou Shin, 2021; Reda et al, 2022). In addition, it might strengthen the restoration and increases its durability under occlusal forces in addition to ease of fabrication, (Saleh and Taşar-Faruk, 2019). Many dental types of cement have been developed to fix the restorations over the implants (Rezapour et al, 2022; Jakovac, 2022). Cement may be used as a long-term or short-term luting agent (Aladag et al, 2020; Mohajerfar et al, 2021). Many types of resin cement were introduced for the cementation of fixed prostheses (Shen et al, 2021; Shen et al, 2022). Recent advancements have attempted to eliminate a few clinical processes like etching, priming, and bonding, allowing prostheses to be bonded directly onto clean abutments with single-component material. One of the most widely recommended permanent cement for implant-supported restorations is self-adhesive resin cement (Saleh and Taşar-Faruk, 2019). As a permanent replacement for a lost tooth, this procedure may be coupled with dental implant immediate loading. Load transfer should limit surface damage while providing tension stress at the cementation interface (Bergamo et al, 2019; Ioannidis et al, 2020). Cement interface space might have a crucial impact on affecting ceramic fracture strength and resistance (Almehmadi et al, 2019; Liu et al, 2020; Moriya et al, 2020; Bjelopavlovic et al, 2022). Few studies conducted the interface space dimension with implant restoration regardless of the implant materials. Rosentritt et al. showed in their in vivo study that the mean fracture resistances of 100µm cement thicknesses in cement-retained molar crown supported-implant were greater than that of the screw-retained crown (Rosentritt et al, 2017). However, Sallma et al, (2017) after using different crowns and implant abutment designs found that the hybrid crown of 80µm gap cement with ceramic implant abutment had lower fracture resistance (Sallam, 2017). Generally, the increase in cement depths might lead to a decrease in the structural deterioration of ceramic crowns. Yet, according to Moilanen et al, 2018, the cement gap size of the interface space might have a significant influence on fracture resistance (Moilanen et al, 2018). Many studies stated that the cement gap for implant restorations is clinically acceptable at 150µm (Huang et al, 2015; Pan et al, 2021; Rutkunas et al, 2022). However, no studies reported assessing the effect of interface cement gap on the fracture load of cement-retained hybrid crown-supported mono-implant. Therefore, the present study was designed for this purpose.

Materials and methods

Fourteen mono-implant abutments (DeTech, Ankara, Turkey) were used in this study. They were attached and embedded in acrylic resin blocks (Takilon, Germany) with the aid of a dental surveyor (Figure 1), radiopaque elastics were used to locate the neck of the mono-implant abutment (Ortho Technology, UK). The mono-implant abutment was scanned using a (3D shape) unit. A single mono-implant STL file was then exported to the CAD/CAM machine (DeguDent, brain MCXL, Germany) to design the maxillary right molar (Figure 2). The crown was designed with the following parameters: the molar of full anatomy with a thickness of 1mm and a marginal thickness of 1.2mm. Two interfaces cement spaces of 80µm and 160µm applied to the molar design (n=7). The Vita Enamic® hybrid material is used to create the crowns (VITA Zahnfabrik, Germany). The crowns of both groups were cemented using self-adhesive universal resin material (U-Cem, Vericom, Republic of South Korea). Subsequently, the surface was non-silanated, and then resin material was injected using an auto-mix syringe for 10sec. Afterwards, the crowns were originally positioned on their respective abutment screw with finger pressure for 2-3sec, then placed instantly in a seating pressure device. A standardized pressure of 50g/mm2 through a plunger of 10mm diameter was applied for 5min (Roy et al, 2017; Dauti et al, 2020). After 1min, the excess cement was carefully removed from the margin by the dental probe. The specimens were then kept for the testing procedure (Figure 3). For the fracture load testing procedure, and to provide a homogenous stress distribution, a cushion of light-body silicone was placed between the specimen and the load transfer arm (Rubber dam, Ivory®) (Al Marza, 2015; Nakamura et al, 2016). A universal testing machine (Instron, 1195) was used to test the specimens under load at fracture, and a crosshead speed of 1mm/min with a maximum set load of 5000N exerted on the occlusal surface of each crown until the fracture (Figure 4). The highest breaking load of each specimen was recorded in Newton (N) (Weyhrauch et al, 2016).

Results

The findings of the study analysis of the hybrid crown cement-remained mono-implant performed to evaluate the load at fracture were presented in Table (1) and Figure (5). To determine the statistical difference between the study groups, a student t-test was applied. There was a statistically significant difference between the cement space of 80µm and 160µm (P≤0.001). The higher mean fracture load value was in a hybrid crown of 80µm cement space (2179 (±97))N, while the lower value was in a hybrid crown with cement space of 160µm (1814 (±102))N.

Figure (1): Mono-implant embedded in acrylic resin blocks with the aid of a dental surveyor.

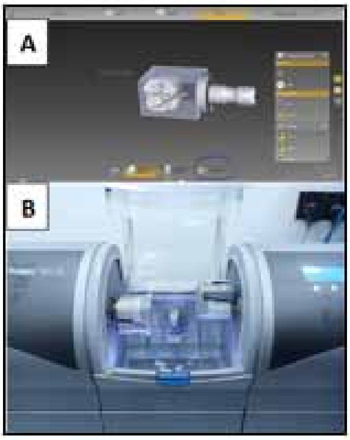

Figure (2): A, The design of full anatomy 1st molar crown using CAD system: and B, Milling the Vita Enamic® using CAM production method.

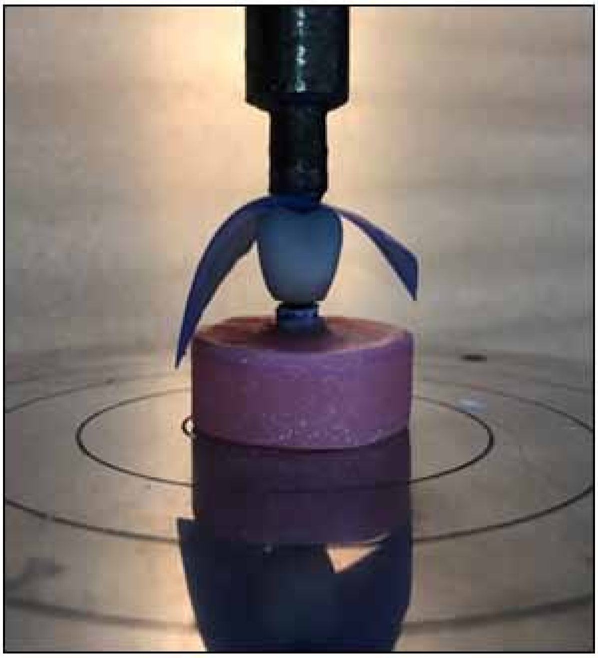

Figure (4): Hybrid molar crown cement-retained mono-implant under load until fracture.

Figure (3): Study specimens grouped for the testing procedure.

Table (1): Student t-test show the statistical analysis of the studied groups.

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Load at Fracture	Equal variances assumed	.137	.718	6.836	12	.000	364.85714	53.37622	248.56036	481.15393
	Equal variances not assumed			6.836	11.972	.000	364.85714	53.37622	248.53023	481.18406

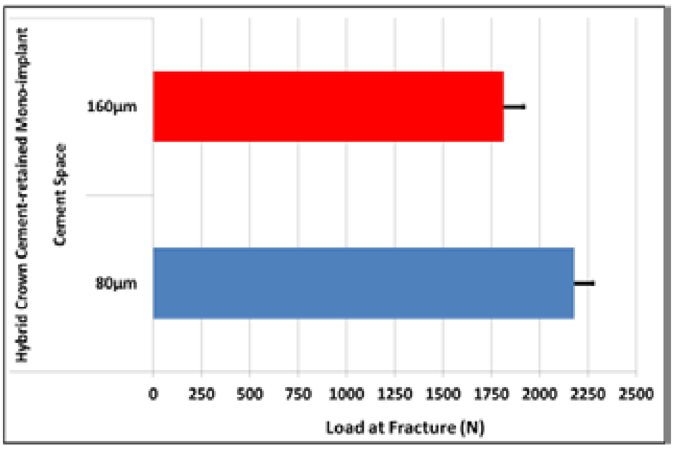

Figure (5): Mean distribution of the load at fracture of hybrid crown cement-retained mono-implant with two different cement interface space.

Discussion

Vita Enamic® Hybrid ceramics have been widely accepted as crowns material for posterior regions using CAD/CAM production method. This might be related to higher chipping or fracture resistance under functional loads (Adolfi et al, 2020; Rohr et al, 2021). Although the use of hybrid crowns has become common for implant purposes, referred procedures do not exist regarding cement interface intervals with mono-implant. This study assessed the effect of 80µm and 160µm cement interface gaps on the fracture resistance of a hybrid crown-supported mono-implant. As a result, the cement interface gap values applied in the current investigation were based on published assessments of misfits of hybrid crowns manufactured using CAD/CAM systems (Lin et al, 1998; Reich et al, 2005). The present study data showed higher static fracture resistance in the hybrid crown restoration over mono-implant between that 80µm and 160µm of interface cement gap. The lowest static fracture resistance was noticed with 160µm cement space of 1814(±102)N compared to that of 80µm of 2179(±97)N. This could disagree with Rosentritt et al. who found fracture resistance of 1385.5(±249.4)N with a 100µm cement gap of the maxillary hybrid crown, but after thermocycling (Rosentritt et al, 2017). According to the manufacturer and some studies, the Vita Enamic® crown should be used with sufficient geometry dimension of the implant abutment with at least 0.8mm cervical support of the crown on the abutment shoulder (Edelhoff et al, 2019; Miura et al, 2022; Yadav et al, 2023). Yet, the present study used a mono-type implant with no finish line, in addition to two different interface cement gap spaces with a crown of a free marginal thickness of 1.2mm. It seems that the increase in the cement gap for more than 80µm might decrease the fracture resistance of Vita Enamic® crown cement-retained mono-implant. The lower fracture resistance of the hybrid crown with 160µm cement space might be explained by an increase in the lever arm generated by 2mm cervical abutment exposure without crown coverage. The current hybrid crown results on abutments without a finish line cannot be compared to any other because no other study has evaluated the mechanical behaviour of crown cement to abutment without a finish line, and all previous studies have only considered the abutment. Therefore, shortly and according to these study findings, posterior single crowns made of Vita Enamic® could be used with implant abutment without a finish line and different cement gap interfaces.

Conclusions

Within the scope of this research, it is possible to conclude that hybrid ceramic crowns of 80µm and 160µm cement spacers for cemented mono-implant had a significant influence on fracture resistance. Users of mono-implant-supported restoration are finding it increasingly difficult to navigate the various new techniques and materials. As a result, a sufficient level of prior knowledge is required to apply the large range of alternatives intelligently and successfully.

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