MJMR, Vol. 34, No. 2, 2023, pages (176-185)

Open Access
ISSN: 2682-4558

Research Article

Effect of Two Different Bar materials on Axial Retention Forces of Implant-supported Mandibular Overdentures

Ahmed Salah Mohammed, Doaa Tawfik Hassan, Amr Mohammed Ismail, and Gehan Fikry Mohammed
Department of Removable Prosthodontic, Oral and Dental Medicine, Mania. Egypt

DOI: 10.21608/MJMR.2023.411013

Abstract
The retention for overdenture attachments depends on design, location, alignment of supporting dental implants and the type of attachments. The goal of this in vitro study was to evaluate and measure retention between PEEK and ZIRCON milled bar materials in implant-supported over-denture prosthesis. An overdenture with titanium framework was made on an edentulous mandibular model with 4 OXY implants Piesse line (3.5 X 11.5mm) in the canine and premolar area connected with two different bar materials. The overdenture attachments were subjected to 5 consecutive pulls on a universal testing machine with a crosshead speed of 50 mm/min in the vertical directions. The over denture was inserted and removed 3240 times in a vertical direction perpendicular to occlusal plane to simulate prosthesis wearing about 3 years. Another five pulls were made and the mean used to represent final retention values. Analysis of Two-way ANOVA were used to determine differences between mean retention values ($\alpha = .05$) The highest average value retention was recorded for the PEEK bar with in the vertical direction.

Keywords: ZIRCON, PEEK, RETENTION, OVERDENTURE

Introduction
Many patients suffer from the lack of retention of conventional mandibular dentures. The implant supported overdenture could be regarded as a geriatric treatment modality for patients who could not withstand prolonged oral surgeries and offers them a treatment alternative that is reliable and that provides phonetic, hygienic, esthetic and economic advantages. Mandibular implant-supported overdenture treatment has also reduced various denture complaints and has scored high patient preference.(1).

To increase retention, attachments were introduced such as ball and socket, magnets, locators and bars. Different attachment system used as means of improving the retention and stabilization of Overdentures with different longevity, biomechanics and functionality.(2).

One of the factors that influences the amount of force transmitted to the implants is the type of attachments used to connect them to the denture. Various types of attachments could be used to retain, support, and stabilize these Overdentures. The most commonly used types include ball and sockets, locator, magnets, bars, and telescopic coping.(3).

Bar attachment is more commonly used systems for anchorage which provide greater retention, stability, resist lateral and rotational movement, enabling better force balance by its splinting effect and reduce loading force over implants and aid in correcting misaligned implants.(4).

Nowadays, implant supported attachments provided greater retention and stability. However, implant bars fabricated using the conventional technique may not routinely

produce the desired fit between implants and implant bars.[5].

Bars can be fabricated from different materials. The comparison of retention values given by each material seemed to be a point of worthy investigation. Accordingly, this study was conducted to high light this aim

Aim of the study

The aim of this study is to evaluate mean retentive values in two different milled bar materials (PEEK/zircon) in implant supported mandibular over dentures using the universal testing machine.

Materials and Methods

This study was carried out on an edentulous mandibular acrylic resin model. (Fig. 1). A resilient soft liner of 2mm thickness covering the mandibular ridge was constructed to match oral mucosa. An acrylic denture base was constructed on a stone model duplicated from acrylic model. A complete set of mandibular artificial teeth on the acrylic denture base was made to be used as a guide for implant placement. (Fig. 2). Four implants, 3.5 mm in diameter and 11.5 mm in length were installed in the canine and premolar area using the guide template. Implants were placed using spiral drill mounted to a parallometer device (Mestra Spain).

The implants were screwed to the model and fixed using self cure acrylic resin to stimulate osseointegeration.[6].

Four straight multiunit abutments were torqued to the implants at 15 Ncm then four scan bodies were attached to the multiunit abutment and scanned inside desktop to obtain a detailed digital 3D image file and electronically transmitted the file to the exocad software for designing of the bar. (Fig. 3).

The exocad software interface was opened and started to insert of the planning for designing of the screw retained rectangular bar. A bar pillar were selected on both canines and second premolars while a bar segments for others and a bite splint were selected for the opposing side. (Fig. 4).

Tooth models were placed as a contact point of distal adjacent teeth for canine and second premolar on both side and teeth were placed from five to five. (Fig. 5).

The parameter of bar was introduced as 2mm away from ridge,5mm height and 4mm width.[7].

Generating the abutment bottoms of the bar and detected the screw channels. (Fig. 6). The gap width for the superstructure was selected 50 micron.[8].

The bar design was ready for sending to milling machine. The polyether ether ketone (PEEK) material was the first milled bar material of choice and the other one was zircon. (Fig. 7). Overdenture with titanium framework was constructed over the bar by selecting a bite splint module on the interface of the exocad software for the opposing to resemble the titanium frame work. The bite splint bottom was designed by block out the undercut and then design the bite splint top by drawing the bite splint margin line and free forming for the top were done. Bite splint design file was send to milling machine for milling. Then ring designed over the titanium framework placed on the geometric center. Titanium framework was waxed up by free hand and a wax mesh was placed all over the ridge. (Fig. 8)

A sprue wax rod was placed as a triangular, the apex between the 2 central areas and the base at retro-molar area then a sprue wax line extended vertically divided the triangular in to two triangular then another sprue wax extended from retro-molar area to the center of this line. (Fig9).[9].

The universal testing machine was used to measure the retentive forces of the studied attachments. (Fig10). A vertical tensile force was applied to the metal ring at a speed of 50 mm/min untill the attachment separated. This speed stimulated the speed of overdenture displacement away from the tissue during mastication.[10].

Data were collected, tabulated and statistically analyzed.

Data presented as mean, standard deviation (SD), Minimum, and Maximum when appropriate. Data explored for normality using Anderson-Darling test. Retention forces (N) showed normal distribution, so two-way ANOVA used to compare between two groups and cycling followed by Tukey HSD for pair wise comparison.

The significance level was set at $p < 0.05$.

Statistical analysis was performed with IBM® SPSS® (ver. 26. SPSS Inc., IBM Corporation, Armonk, NY, USA).

Fig. 1

Fig. 2

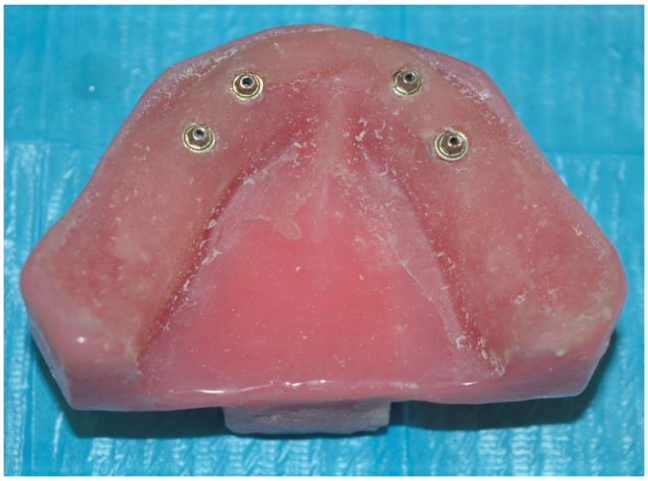

Fig. 3

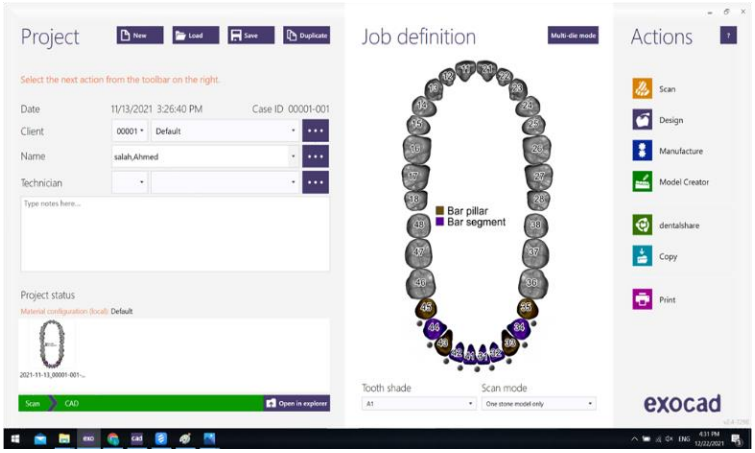

Fig. 4

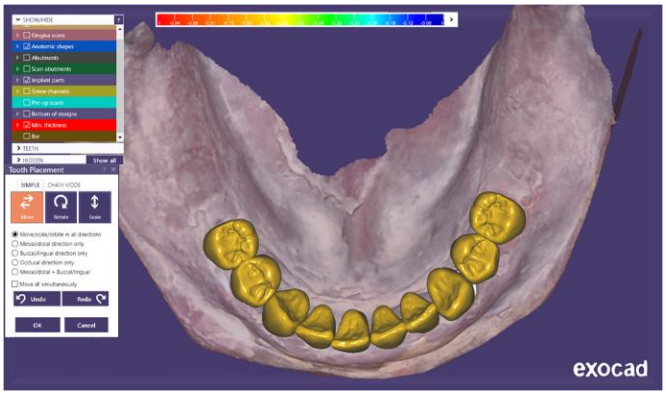

Fig. 5

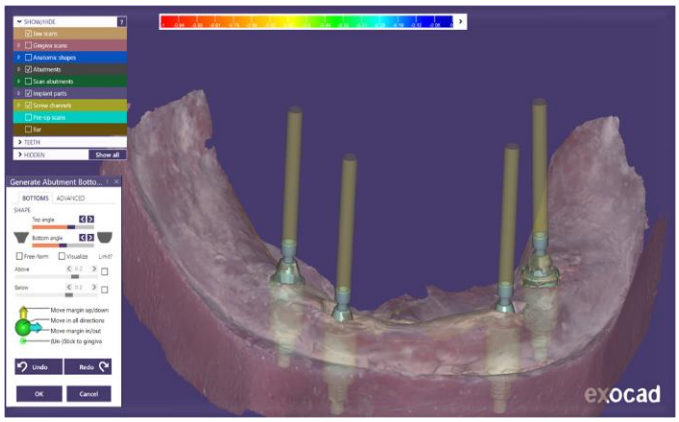

Fig. 6

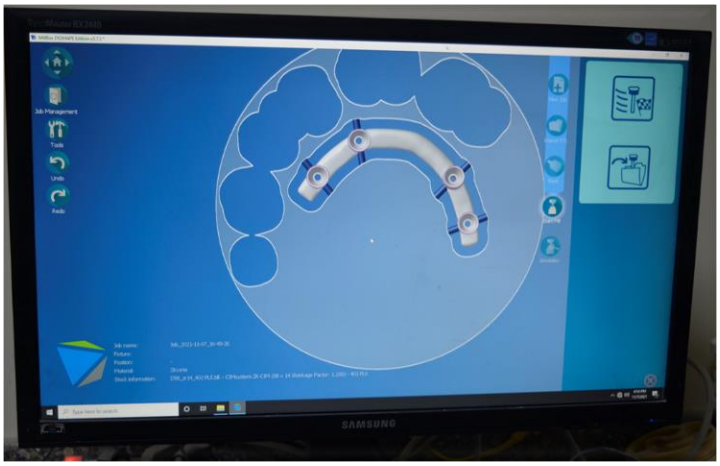

Fig. 7

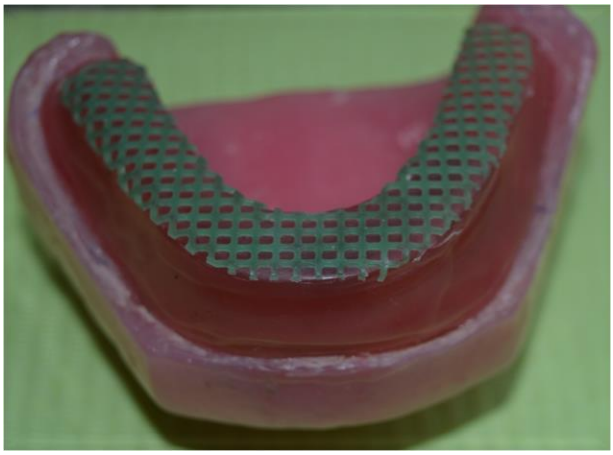

Fig. 8

Fig. 9

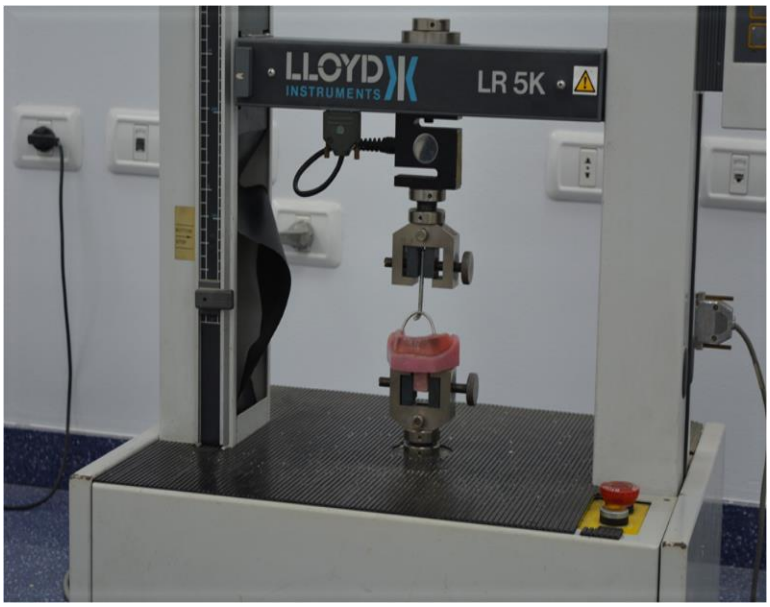

Fig. 10

Results

1. Effect of different tested groups

Results of Retention Force (N) for different tested groups are presented in table 1 and (fig.1). Before cycling; PEEK (73.42±6.66) showed higher significant Retention Force (N) followed by Zircon (16.52±5.8) at p<0.001. After cycling, PEEK (111.49±5.74) showed higher significant Retention Force (N) compared to Zircon (19.76±1.81) at p<0.001.

Table1: Mean and Standard deviation (SD) results of Retention Force (N) for thermo-cycling for different groups.

	PEEK				Zircon				p-value
	Mean	**SD**	**Min**	**Max**	**Mean**	**SD**	**Min**	**Max**	
Before	73.42[a]	6.66	68.19	85.4	16.52[c]	5.8	9.9	26.49	<0.001*
After	111.49[a]	5.74	106.74	118.61	19.76[b]	1.81	16.64	21.04	<0.001*

Different letters within each row indicates significant difference at p<.05
***=significant, NS=non-significant**

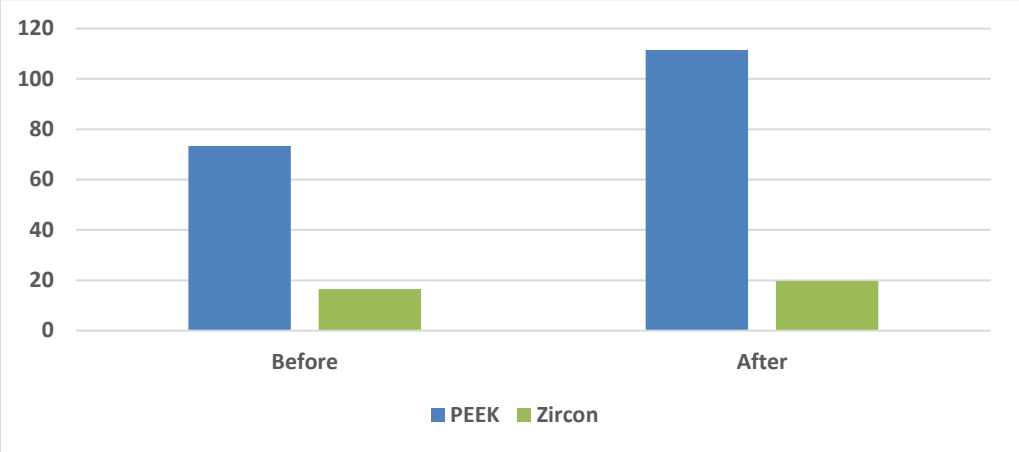

Figure 1: **Bar chart showing means Retention Force (N) for different tested groups before and after cycling.**

2. Effect of cycling

Results of Retention Force (N) for different tested groups are presented in table 2 and figure 2. For PEEK group, cycling (111.49±5.74) resulted in significant increase in the Retention Force (N) compared to before cycling (73.42±6.66) at p<0.001. On the other hand, for Zircon group, cycling (19.76±1.81) resulted in an insignificant difference in the Retention Force (N) compared to before cycling (16.52±5.8) at p=0.645.

Table 2: Mean and Standard deviation (SD) results of Retention Force (N) for cycling for different groups.

	Before				After				p-value
	Mean	SD	Min	Max	Mean	SD	Min	Max	
PEEK	73.42	6.66	68.19	85.4	111.49	5.74	106.74	118.61	<0.001*
Zircon	16.52	5.8	9.9	26.49	19.76	1.81	16.64	21.04	0.645 NS

***=significant, NS=non-significant**

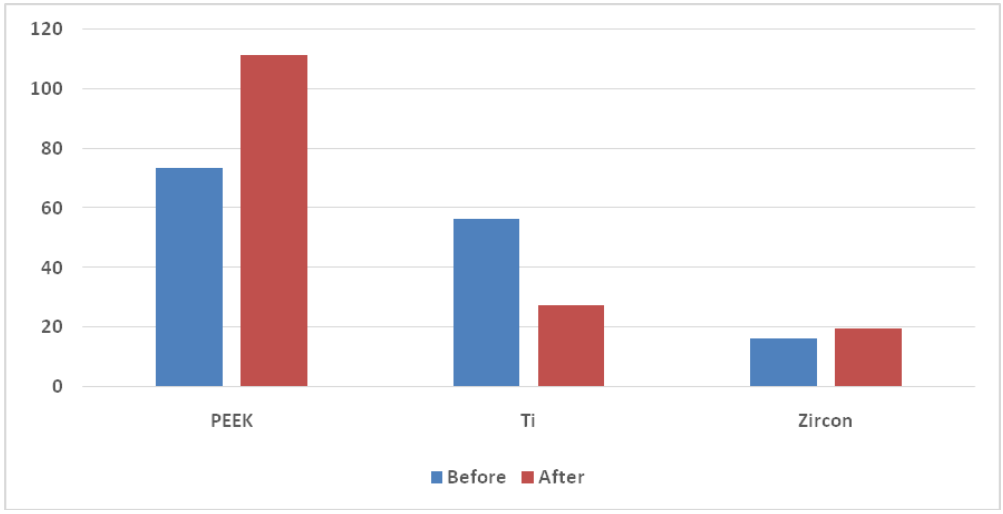

Figure 2: Bar chart showing means Retention Force (N) for effect of cycling for each group.

Discussion

The choice of prosthetic implant supported over dentures has depended on data from previous studies. Little data have been available on the correlation between the attachment system selected and the over denture support configuration. The purpose of this study was to evaluate the retention force of two milled bar attachment systems and over denture prosthesis. The loss of retention of attachment is one of the authentic factors that will provide the selection of the attachment.[11] A model was constructed from heat cure acrylic resin represent a completely edentulous mandible to resist the anticipated loading force during the experiment. Soft liner was added to the residual ridge to stimulate the viscoelastic behavior of mucous membrane covering the residual ridge. Four identical implants were inserted at the canine and second premolar regions perpendicular to the occlusal plane and parallel to each others to reduced stress concentration area between them. A milling machine was used to perform the drilling sites of the implants to avoid any errors in angulations. A mix of chemically activated acrylic resin was used to fix the fixture in the drilling sites which was used to stimulate the process of osseointegeration.[12]. Four multiunit abutments were threaded to implant fixtures as a connecting unit between implant prosthetics and implant body to avoid complications during prosthetic reconstructions and to retrieve the prosthesis.[13].. Four digital scan bodies were connected to implant fixture to digitally capture implant positions and to developed CAD/CAM restorations and digital workflows. .[14].

Exocad software was choosing for designing and planning because its faster workflows, improved proficiency and easy to used for dentists and technicians.

The selection of titanium frame work was favorite options due to previous studies about the toxicity and biological effects of cobalt chromium that mentioned, chromium is passivated by oxygen forming a thin protective oxide surface layer with another element such as iron or nickel, preventing diffusion of oxygen in to the underlying material.[15].

Due to financial issue and expensive of titanium framework we used the same frame work with the new zircon bar but after obtained a negative replica for the framework by spraying the fitting surface smoothly with very little flake formation to facilitated the scanning of difficult surface because the fitting surface was too shiny, too transparent and difficult to capture and some wear absolutely was happened in the fitting surface.[16].

Generally, the results showed that cycling result in increase in the retention force (N) with time for the PEEK attachment. On the other hand, insignificant different in the retention force (N) for zircon attachment compared to before cycling.

These removal and insertion cycles were considered correspondent to total of three years usage period of actual clinical mode of wear the attachment based on the assumption that a patient removes his denture three times daily. The selection of these periods without interval to compensate the patient oral environment under regular circumstances such as patient position, tongue size and to simulate the wet oral environment.[17].

The retentive force value is very important, and is the most fundamental consideration in the selection of attachment systems clinically. Previous studies reported that the longevity of attachment systems are affected by factors such as the number and position of the implants, type and material of the attachments, and design of the prosthesis, hence the reason why different types and materials of attachments were considered in this study.[18].

Furthermore, a few studies stated that PEEK may be used as an attachment retaining implant-supported Overdentures. In a clinical study of Mangano et al; 2019, 15 fully edentulous patients were rehabilitated with a maxillary overdenture supported by 4 implants and CAD-CAM fabricated PEEK bar. After a year in function, no implants were lost and an 80% success rate for implant-supported Overdentures was found.[19].

A clinical report also suggested the use of an implant-supported overdenture with the receptor part of the bar milled from PEEK polymerized into a zircon framework for the rehabilitation of an edentulous patient. The authors reported high patient satisfaction with function and esthetics after 6 months. [20].

Conclusion

Within parameters of this study, it could be concluded that both PEEK and ZIRCON can provide comparable retention forces but with higher and significant retentive value for PEEK especially after cycling of insertion and removal of prosthesis.

Reference

1. Marin DOM, Leite ARP, Oliveira Junior NM, Paleari AG, Pero AC and Compagnoni MA .Retention Force and Wear Characteristics of three Attachment Systems after Dislodging Cycles. Braz Dent J. 2018 ;29(6):576-82.
2. Gonçalves F, Campestrini VLL, Rigo-Rodrigues MA and Zanardi PR. Effect of the attachment system on the biomechanical and clinical performance of overdentures: A systematic review. J Prosthet Dent. 2020 ;123(4):589-94.
3. Cozzolino F, Apicella D, Wang G , Apicella A and Sorrentino R.Implant-to-bone force transmission: a pilot study for in vivo strain gauge measurement technique. J Mech Behav Biomed Mater. 2019; 90:173-81.
4. Anas El-Wegoud M, Fayyad A, Kaddah A and Nabhan A .Bar versus ball attachments for implant-supported overdentures in complete edentulism: A systematic review. Clin Implant Dent Relat Res. 2018; 20(2): 243-50.
5. Lee DJ and Saponaro PC. Management of Edentulous Patients. Dent Clin North Am. 2019 ;63(2):249-61.
6. Elsyad MA, Elhddad AA and Khirallah AS. The effect of implant diameter on strain around implants retaining a mandibular overdenture with Locator attachments: An in vitro study. Dent Mater J. 2016;35:938–45.
7. Abdraboh AE, Elsyad MA, Mourad SI and Alameldeen HE. Milled Bar with PEEK and Metal Housings for Inclined Implants Supporting Mandibular Overdentures: 1-Year Clinical, Prosthetic, and Patient- Based Outcomes. Int J Oral Maxillofac Implants.2020;35(5):982-89.
8. Prasad R and Al-Kheraif AA. Three-dimensional accuracy of CAD/CAM titanium and ceramic superstructures for implant abutments using spiral scan microtomography. Int J Prosthodont.2013; 26(5):451-57.
9. Viswambaran M and Agarwal SK.The effect of four sprue shapes on the quality of cobalt-chromium cast removable partial denture frame-works. Contemp Clin Dent.2013;4(2):132-39.
10. Savabi O, Nejatidanesh F and Yordshahian F. Retention of implant-supported overdenture with bar/clip and stud attachment designs. J Oral Implantol. 2013;39(2):140-47.
11. Elkerdawy MW and Radi IAW.Effect of dislodging forces on mandibular implant attachment-retained overdenture. Implant Dent.2011;20(3):246-54.
12. Tabatabaian F , Alaie F and Seyedan K. Comparison of three attachments in implant-tissue supported overdentures: an in vitro study. J Dent (Tehran). 2010;7(3): 113-8.
13. Buzayan MM and Yunus NB. Passive Fit in Screw Retained Multi-unit Implant Prosthesis Understanding and Achieving: A Review of the Literature. J Indian Prosthodont Soc. 2014; 14(1): 16–23.
14. Papaspyridakos P, Rajput N , Kudara Y and Weber HP . Digital Workflow for Fixed Implant Rehabilitation of an Extremely Atrophic Edentulous Mandible in Three Appointments. J Esthet Restor Dent.2017; 29(3):178-88.
15. Behl B, Papageorgiou I, Brown C, Hall R, Tipper JL, Fisher J, and Ingham E. Biological effects of cobalt-chromium nanoparticles and ions on dural fibroblasts and dural epithelial cells. Biomaterials. 2013 ;34(14):3547-58.
16. Dehurtevent M , Robberecht L and Béhin P. Influence of dentist experience with scan

spray systems used in direct CAD/CAM impressions. J Prosthet Dent.2015; 113(1): 17-21.
17. Kang TY, Kim JH, Kim KM, and Kwon JS. In Vitro Effects of Cyclic Dislodgement on Retentive Properties of Various Titanium-Based Dental Implant Overdentures Attachment System. Materials (Basel). 2019; 12(22): 3770.
18. Chung K.H, Chung CY, Cagna DR, Cronin R.J and Jr RJC. Retention characteristics of attachment systems for implant overdentures. J Prosthodont.2004; 13(4): 221-6.
19. Mangano F, Mangano C, Margianin B and Admakin O. Combining Intraoral and Face Scans for the Design and Fabrication of Computer-Assisted Design/Computer-Assisted Manufacturing (CAD/CAM) Polyether-Ether-Ketone (PEEK) Implant-Supported Bars for Maxillary Overdentures. Scanning. 2019: 4274715.
20. Spies BC, Petsch M, Kohal RJ and Beuer F. Digital production of a zirconia, implant-supported removable prosthesis with an individual Bar attachment milled from polyether ether ketone: a case history report. Int J Prosthodont.2018;**31**(5):471–74.