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Marginal Accuracy Analysis of Cast Base Metal Implant Frame Works- An In Vitro Study

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Abstract: *The vertical micro gap between implant and abutment has a vital role in implant survival as well as for prosthetic success. Bacterial colonization may happen in the microgap leading to peri-implantitis. Passive fit between the implant and abutment is a pre-requisite for the prosthetic success. The study compared the microgap of Cast Nickel-Chromium and Cobalt-Chromium abutments with premade abutments made of Grade 5 titanium. 15 implant abutments were divided into 3 groups. Group-1 comprised of 5 pre-made abutments. 10 plastic abutments, of which 5 were cast in Nickel-Chromium (group-2) and 5 were cast in Cobalt-Chromium (group-3). One internal hex implant was embedded in an acrylic resin model. Each standard abutment and cast abutment was tightened on it. The abutment/implant interface for each specimen was analyzed at 6 different locations, using Mitutoyo QV Apex302 Measuring System. Data were submitted to statistical analysis (One Way ANOVA and Duncan's Multiple Range Test, $p < 0.001$). The Mean Marginal Gap in each group was found to be; 15.30 µm (Group-1), 27.17 µm (Group-2) and 30.53 µm (Group-3). It was statistically confirmed that the differences between group 1 and group 2, group1 and group 3 and group 2 and group 3 were, very highly significant.*

Keywords: *Cast abutments, Cast Implant frameworks, Microgap, Premade abutments,Peri-implantitis, Prosthetic failure, Passive fit,Screw loosening.*

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I. Introduction

Invention of dental implants and osseointegration for prosthetic rehabilitation of partially and completely edentulous patients provided long term predictable results. Even though the prosthetic success rates were high, many of the studies revealed high prevalence of prosthetic complications such as screw loosening [1-4]. The microgap which is the vertical gap between implant and abutment is a contributing factor in screw loosening [5]. Bacterial colonization may happen in the microgap leading to peri- implantitis.

It was reported that, when considering the mechanical aspect of the implant prosthesis, poor fitting prosthesis with 6µm to 10µm vertical misfit may lead to screw loosening [4,6]. Another contributing factor for screw loosening and fracture is misfit between the implant abutment interfaces. According to the current scientific evidence and the efficacy of contemporary dental technology used for framework fabrication, it has been concluded that an absolute passive fit cannot be obtained[7]. Another variable that influences the joint stability is how the contacting parts change upon tightening the screw. In order to ensure a better fit, the use of premade components has been highly recommended. The high cost of this type of framework has led to the development of plastic abutments allowing the use of base metal alloys [5].The present study compared the marginal accuracy of Cast Nickel-Chromium and Cobalt-Chromium abutments with premade abutments made of Grade 5 titanium. The study assessed the marginal accuracy of Cast and pre made cylinders using Mitutoyo QV Apex 302 Measuring System.

II. Material and Methods

Ten Plastic abutments and 5 precision milled metallic abutments were used in this study. Among the 10 plastic abutments 5 were cast in Nickel-Chromium and remaining 5 in Cobalt-Chromium alloy. The pre made milled abutments and cast abutments were divided into following 3 groups. Each group comprised 5 samples.Group 1- Five precision milled metallic standard abutments made of Grade 5 titanium (MDMAC10,MIS Implants Technologies Ltd, Israel) were analyzed as received and used as a positive control group (Fig. 1). Group 2- Five cast abutments in Nickel Chromium(Ni-Cr) alloy(WironR 99, Bego Co, Bremen , Germany) (Fig. 2).Group 3- Five cast abutmentsinCobalt-Chromium (Co-Cr) alloy(WironitR, Bego Co, Bremen , Germany) (Fig. 3).

Figure.1. Five precision milled metallic standard abutments made of Grade 5 titanium (MD-MAC10, MIS Implants Technologies Ltd, Israel).

Figure. 2. Cast Nickel-Chromium abutments. ‘

Figure. 3. Cast Cobalt-Chromium abutments

The cast specimens for groups 2 and 3 were made using the plastic cylinders(MD- CPH13, direct plastic cylinder internal hex, MIS Implants Technologies Ltd, Israel). They were invested in phosphate bonded investment (ADENTAR- VEST CB, GERMANY). Each component was casted individually, according to the manufacturers recommendations. Castings were done in a pressure casting machine (Reital, Argon pressure casting machine,Germany). Following completion of casting careful divesting was performed. The specimens were sandblasted and the sprues were cut. The specimens were steam cleansed. After this they were kept in ultrasonic cleaner in distilled water for one minute. Finishing and polishing were not performed.

On an acrylic resin model (DPI- RR COLD CURE, Densplay, Delhi, India), one internal hex implant (MF7-16420, Screw type, internal hex,MIS Implants Technologies Ltd, Israel) was embedded using a surveyor. The resin model was fabricated with a hexagonal shape (3cm x 1.5 cm x 1.5 cm). Each standard and cast abutment was tightened to 35 Ncm on the internal hex implant using a torque wrench. Following this, after a period of 10 minutes each sample was again tightened to 35 Ncm.

2.1Testing the specimens

Implant-Abutment interface of each specimen was analysed at 6 different locations around the interface, according to the resin model design, using Mitutoyo QV Apex 302 Measuring System under 70X magnification (Fig. 4).

Figure. 4. Mitutoyo QV Apex 302 Measuring System

Samples were scanned using high sensitivity CCD camera. The equipment had ameasuring accuracy of (1.5+3L/1000µm on the XY axis, 3+4L/1000µm on Z axis). Analyses were carried out for all groups.The precision milled and cast abutments showed marginal inaccuracies more than the accepted level. The control group (premade abutments) presented better marginal fit than both tested groups. The value of mean marginal gap for cast Ni-Cr abutments when compared with that of cast Co-Cr abutments were found to be comparatively similar (a difference of only 3 µm). Compared to the cast Cobalt-Chromium abutments the cast Nickel-Chromium abutments showed improved marginal accuracy. Successful dental implantation and thereafter prosthetic loading require a higher degree of precision and predictability regarding the implant platform and engaging abutment portion. However, the use of plastic components to cast abutments is very economical. Its usage should be viewed with caution when precision and predictability are desired.

III. Results

The precision milled metallic abutment (Group-1) showed higher marginal accuracy (15.30µm) than the cast Nickel- Chromium and the cast Cobalt- Chromium abutments. Compared to the cast Cobalt-Chromium(Group-3) abutments(30.53µm), the cast Nickel- Chromium(Group-2)abutments(27.17 µm) showed higher marginal accuracy (Fig. 5).The marginal gap observed between the cast Nickel- Chromium and Cobalt-Chromium samples were comparatively less.

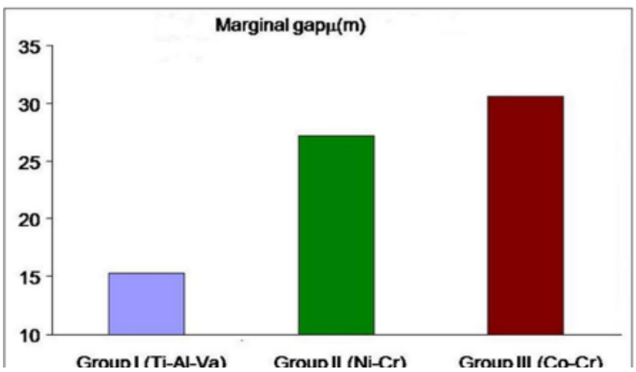

Figure. 5. The graph represents the comparison of mean marginal gap in micro meters for Group 1, Group 2 and Group 3.

3.1Statistical analysis

Data were analyzed using computer software, Statistical Package for Social Sciences (SPSS)version 10. Data are expressed in its mean and standard deviation. Analysis of variance (One Way ANOVA) was performed as parametric test to compare different groups. Duncan's Multiple Range Test was also performed as post hoc analysis enabling multiple comparisons TABLE 1.

TABLE 1. Analysis of variance (ANOVA) comparing mean marginal gap (mm) for different groups of materials

Group	Mean	± SD	F value	P Value
Group I (Ti-Al-Va)	15.30^{a}	2.32		
Group II (Ni-Cr)	27.17^{b}	5.09	129.164	< 0.001
Group III (Co-Cr)	30.53^{c}	3.65		

A, b, c – Means with same superscript do not differ each other (Duncan's Multiple Range Test)

For all statistical evaluations, a two-tailed probability of value, < 0.05 was considered significant. Duncan's Multiple Range Test showed values of $p < 0.001$ for comparison between group- 1 and group- 2, group- 1 and group- 3 and group- 2 and group- 3. It was statistically confirmed that the differences between group 1 and group 2, group1 and group 3 and group 2 and group 3 were, very highly significant.

IV. Discussion

Implant abutment restorative interface usually creates a space. This space is referred to as micro gap. For the majority of segmented implant systems, an implant-abutment assembly spells marginal discrepancies and micro gaps at the implant abutment interface [8]. Passive fit and simultaneous, even mating of the complete inner surfaces of implant and abutment is a prerequisite for the maintenance of implant-abutment interface. Passive fit or zero strain between the implant abutment interface is essential to avoid strain on the supporting implant fixture and to the surrounding bone in the absence of an applied external load [9-11]. It was found that, poor fitting prosthesis with 6µm to 10µm vertical misfit may lead to screw loosening [5]. It has been concluded that if an absolute passive fit cannot be obtained betweenImplant abutment interface, this may lead to prosthetic complications such as loosening or fracture of the of the screws that retain the prosthesis to implant [12-15].

In this study, fifteen implant abutments were divided into three groups. First group comprised of five pre- made metallic abutments. Ten plastic abutments, of which five are cast in nickel chromium (group-2) and five are cast in cobalt chromium (group- 3). When the Implant and abutment are tightened ideal expected vertical gap is zero. To enable the abutment to enter the standard platform of the internal hex implant, the milling process should incorporate a tolerance for this [16]. The abutment surface to be milled a little smaller than the interface of implant fixture. This results in a milling, of the abutment fitting surface a little smaller than the implant platform, in micrometer level [16]. During examination of the samples using Mitutoyo QV Apex 302 Measuring System under 70X magnification, a mean marginal gap of 15.30 µm for group one,27.17 µm for group two and 30.53 µm for group three were found. Major reason for this deviation from normal may be an attribute due to milling procedure. No milling procedure can produce two beveled surfaces of same kind. This may lead to discrepancies and microgap[17]. This again can result in tilting and rocking of the abutment and prosthesis.

When implant and abutment are tightened with the specified 35Ncm, force is transferred through the abutment, screw thread and implant thread surfaces. This clamping force generates a preload in the screw which keeps the components together. During this process a part of the tightening force applied will be used in smootheing the mating surfaces of the implant and abutment [18]. This loss in preload is called "settling,'' - the screw loses a part of its preload [19]. Higher the preload, greater will be the force required to loosen the screw. Even after tightening the screw to the manufacturers' instructions, it has been noticed that micro spaces exist between the mating surfaces of the implant and abutment resulting in undesirable movements leading to mechanical failure [20-22].

Stefania Carvalho Kano; Gerson Bonfante et al in a study compared the vertical misfit obtained after casting procedures when plastic cylinders and external hex pre-made cylinders were used [5]. Compared to the present study, both of the studies demonstrate that casting procedures influence the microgapbetween the implant abutment interfaces. Marginal misfit observed may be due to the initial misfit that existed prior to the casting, between the implant and plastic cylinders [5, 16]. Premade abutments exhibit smaller microgap when compared to castable abutments due to the manufacturing technique [23-24]. Microgap of metallic premade abutments may vary from 12 µm to 22 µm 8. Casting procedures result in production of irregularities on the surface. There exist limitations in reliable finishing and polishing techniques to produce a surface free of irregularities. All these factors contribute to microgap formation. There exist multiple variables while casting plastic components for the fabrication of the implant superstructure [5, 16]. Compared to premade abutments, cast abutments are quite inexpensive. Certain clinical situations demand cast abutments. However, precision and success of cast abutments cannot be predicted.

V. Conclusion

The study revealed that the control group (premade abutments) presented better marginal fit than both tested groups. The value of mean marginal gap for cast Ni-Cr abutments when compared with that for cast Co-Cr abutments were found to be comparatively similar (a difference of only 3 µm). Compared to the cast Cobalt-Chromium abutments the cast Nickel-Chromium abutments showed improved marginal accuracy. Successful dental implantation and thereafter prosthetic loading require a higher degree of precision and predictability regarding the implant platform and engaging abutment portion. However, the use of plastic components to cast abutments is very economical. Its usage should be viewed with caution when precision and predictability are desired.

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